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WATER QUALITY STUDY

LOWER BEAR RIVER BASIN, UTAH

PUBLIC HEALTH SERVICE, WASHINGTON, D.C.

FEBRUARY 1960

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U. S. Department of Health, Education, and Welfare
Public Health Service
February 1960

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The water quality in the lower Bear River Basin, Utah, was examined to assist the Bureau of Reclamation in planning reclamation projects in the area and to assist the Utah Water Pollution Control Board in controlling water pollution problems there. Focus was on the chemical and bacteriological quality of the Lower Bear River and its tributaries as well as with the discharge of wastes into the Bear River that affect water quality. Tne discharge of untreated and partially treated industrial and domestic wastes was found to be largely responsible for the high bacterial content of the river water at most of the sampling stations. High salt content was also found near Corinne, making the water unsuitable for most domestic and industrial purposes.

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17b. Identifiers/Open-Ended Terms

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*River basins	*Water pollution sampling
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Utah	Corinne(Utah)
Domestic wastes	Salt water intrusion
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WATER QUALITY IN THE LOWER BEAR RIVER BASIN, UTAH

by

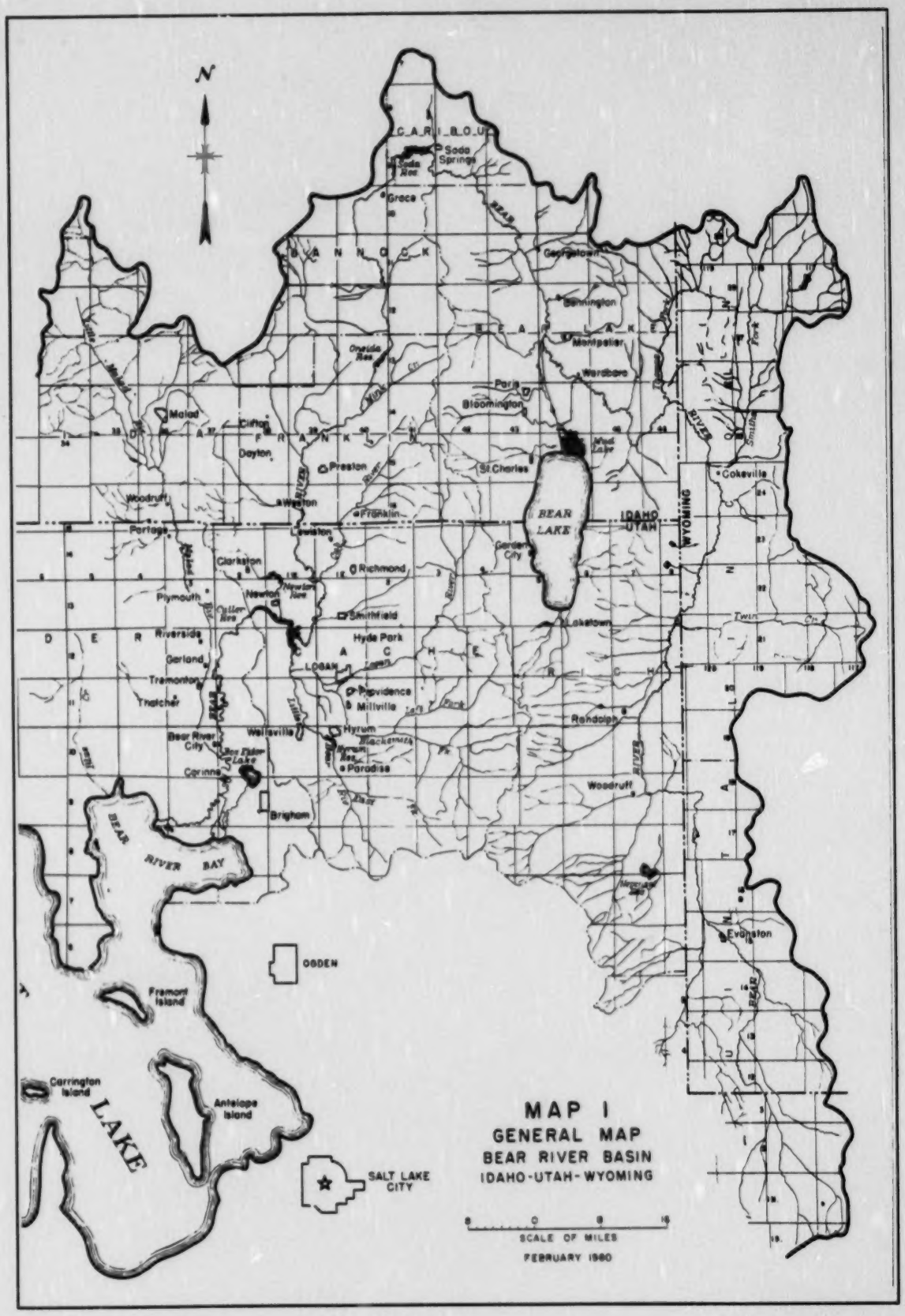
Garry L. Fisk

Sanitary Engineer

Department of Health, Education and Welfare

Public Health Service

February 1960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Dayton
Preston
St Charles
Mud Lake
Cokeville
Woodruff
Weston
Franklin
BEAR LAKE
IDAHO
UTAH
WYOMING
Portage
Garden City
Clarkston
Richmond
Plymouth
Newton
Smithfield
Logan
Hyde Park
Riverside
Garland
Tremonton
Thatcher
Providence
Millville
Hyrum
Wellsville
Bear River City
Corinne
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Brigham
Randolph
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BEAR RIVER BAY
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Fremont Island
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GREAT SALT LAKE
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GENERAL MAP
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WATER QUALITY IN THE

LOWER BEAR RIVER BASIN, UTAH

by

Garry L. Fisk - Sanitary Engineer

Introduction

Consideration has been given to the water quality in the Lower Bear River Basin, Utah, in accordance with the memorandum of agreement dated July 15, 1958 (Appendix A, Exhibit I), supplemented by memorandum of May 25, 1959 (Appendix A, Exhibit II), between the Bureau of Reclamation, Region 4, and the Utah State Department of Health.

This joint study was made primarily to assist the Bureau of Reclamation, Region 4, in planning reclamation projects in the Lower Bear River Basin and to assist the Utah Water Pollution Control Board in controlling water pollution problems in this area. Water samples were collected from select sampling stations throughout the area covering the period from July 1958 through September 1959. The study is concerned with the chemical and bacteriological quality of the Lower Bear River and its tributaries as well as with the discharge of wastes into the Bear River that have an effect upon water quality.

Previous studies on the pollution of the Bear River are covered in the following reports:

1. Report on Interstate Water Pollution in the Bear River Watershed. October 1952. Federal Security Agency. Public Health Service, Division of Water Pollution Control. California and Great Basin Drainage Basin Office. San Francisco, California.

2. Report on the Investigation of Pollutions in the Bear River System. Idaho - Utah. February 1955. U. S. Department of Health, Education, and Welfare, Public Health Service, Sanitary Engineering Services Region IX. Water Supply and Water Pollution Control Program.

3. Water Pollution Studies. Lower Bear River Basin. September 1956. U. S. Department of Health, Education, and Welfare, Public Health Service. Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

4. Water Quality in the lower Bear River Basin, Interim Report, March 1959, C. T. Wright, Department of Health Education, and Welfare, Public Health Service.

Description of Basin

The Bear River drainage basin (Map 1) covers the northeastern section of the Great Salt Lake Basin, including southeastern Idaho, northern Utah, and southwestern Wyoming. The basin area of 7,100 square miles (2,700 in Idaho, 2,920 in Utah, and 1,490 in Wyoming) constitutes less than one-seventh of the area of the Great Salt Lake Basin, but within this area are concentrated more than two-fifths of the water resources and irrigated land of the basin.

The Bear River rises at elevations above 12,000 feet in the Uinta Mountains in Utah. It flows north into Wyoming through Evanston, returns to Utah, and then re-enters Wyoming. It then enters Idaho, bears south into Utah, and eventually flows into Bear River Bay, an arm of the Great Salt Lake. The total length of the river is about 500 miles although its mouth is but 90 air miles from its headwaters. Near Montpelier, Idaho, part of the river is diverted into Bear Lake via Rainbow Inlet Canal. Bear Lake is operated by the Utah Power and Light Company as a multiple-purpose reservoir to provide storage for power generation, irrigation, and maintenance of the river's summer flow in dry years. The major tributaries of the Bear River in the study area are the Cub, Little Bear, and Malad Rivers.

This study is concerned with the Lower Bear River between the Idaho-Utah border and the outlet into Bear River Bay of Great Salt Lake. In this reach of the Bear River the flow is affected by irrigation diversions and return flows, storage reservoirs, and power developments. The storage reservoirs are solely for power purposes and they vary in capacity from 200 to 16,000 acre-feet. This system of flow and storage regulation results in very low summer flows, largely irrigation return flow during the dry years.

Population

Settlement in the Bear River Basin is restricted almost entirely to the valley areas and mainly to the irrigated sections. The population of the basin in 1950, based on estimates from census reports, was 76,654 (Table I), of which about 36,000 reside in sewered communities. Roughly 11 percent of the urban dwellers are in Wyoming, 28 percent in Idaho, and 61 percent in Utah.

Table I
Population distribution by States
(Estimated from 1950 census reports)

State	Total in basin
Idaho	25,654
Utah	45,170
Wyoming	5,830
Total	76,654

The largest community in the basin is Logan, which ranks fourth in size in the State of Utah. Communities in the basin with populations of more than 2,000 are shown in Table 2.

Table 2
Communities with populations over 2,000

Community	County	State	1950 Census
Evanston	Uintah	Wyoming	3,863
Logan	Cache	Utah	16,832
Malad	Oneida	Idaho	2,715
Montpelier	Bear Lake	Idaho	2,682
Preston	Franklin	Idaho	4,045
Smithfield	Cache	Utah	2,383

Existing Development

The economy of the Bear River Basin is based almost entirely upon agriculture, which provides direct support for about 45 percent of the population. Industrial activities are primarily confined to processing of agricultural products. Three beet-sugar refineries, three milk condenseries, two vegetable-canning plants, two phosphate plants, two meat-packing plants, and several dairy products plants comprise the principal industries.

During 1950, about 500 irrigation systems owned and operated by separate irrigation organizations and individuals served about 483,000 acres of irrigable land. The number of irrigation systems and the acreage of irrigated land have not increased greatly since 1910. Irrigation enterprises in the basin remain predominantly cooperative and consist mainly of nonprofit mutual irrigation companies.

Few of the irrigation systems have any storage facilities. Only seven reservoirs with capacities of 1,000 acre-feet or more have been developed by private organizations to store water of the Bear River System for irrigation use. Three additional reservoirs--Hyrum, Newton, and Sulpher Creek--have been developed. The first two by the Bureau of Reclamation, the last by the State of Wyoming. All of these reservoirs are located on tributaries of the Bear River and afford little regulation of the main stem.

Table 3
Irrigation reservoirs--Bear River Basin

Reservoir	State	Stream	Active cap. (acre-feet)
Hyrum	Utah	Little Bear River	15,280
Twin Lakes	Idaho	Mink Creek[1/]	13,950
Neponset	Utah	Bear River[1/]	6,000
Glendale	Idaho	Worm Creek[2/]	5,780
Newton	Utah	Clarkston Creek	5,370
Sulpher Creek	Wyoming	Sulpher Creek	4,100
Lamont	Idaho	Cub River[1/]	2,400
Henderson	Idaho	Deep Creek	2,000
Weston	Idaho	Weston Creek	1,500
Strongarm	Idaho	Battle Creek	1,200

1/ Located offstream. Stream indicated is source of storage water.
2/ Cub River is main source of storage water.

Bear Lake, which is utilized as a storage reservoir, has afforded complete regulation of the upper portion of the Bear River. This reservoir was developed by power interests primarily for power production. It has been of considerable service to irrigation, but mainly in the area under the Hammond and West Side Canals. This area receives stored water from Bear Lake in accordance with a contract between the Utah Power and Light Company, which operates the control works at Bear Lake, and the

Utah-Idaho Sugar Company, which operates and maintains the Hammond and West Side Canals. During the 1924-48 period the Hammond and West Side Canals diverted an average of 208,000 acre-feet annually, much of which was storage water released from Bear Lake. A few additional irrigation systems received much smaller amounts of stored water from Bear Lake.

Streamflow

Natural flows of the Bear River and most of its tributaries vary rather widely at different times of the year and also from year to year. Most of the streamflows originate in the mountainous areas where the snowfall and rainfall are comparatively heavy. Depending mainly upon the amount of snowfall in December, January, and February, the annual flows of the larger streams ordinarily vary from 40 to 175 percent of normal.

Each year during the spring, melting snow in the mountains causes the streams to rise to high stages. About three-fifths of the annual streamflow ordinarily occurs during April, May, and June. On the main stem minimum flows usually occur during July, August, September and October.

Flows of the Bear River at various points along its course and of some of the principal tributaries are summarized in Table 4.

Table 4
Streamflows--Bear River Basin

Stream and location*	Period	Flows			Average Annual (ac.-ft.)
		Maximum (cfs)	Minimum (cfs)	Average (cfs)	
Bear River near Utah-Wyoming State line	1942-58	2,800	16	189	136,800
Bear River near Woodruff, Utah	1942-58	3,010	0	215	155,700
Bear River near Randolph, Utah	1944-58	2,660	5.2	202	146,200
Smiths Fork near Border, Wyo.	1942-58	1,500	35	199	144,100
Bear River at Border, Wyo.	1937-58	3,680	30	410	296,800
Thomas Fork near Wyoming-Utah State line	1949-58	869	2.6	57.2	41,410
Bear River at Harer, Idaho	1919-58	4,400	26	514	372,100
Bear Lake Outlet Canal near Paris, Idaho	1922-58	1,870	1	343	248,300
Bear River at Alexander, Idaho	1921-58	4,590	28	749	542,300
Bear River at Oneida, Idaho	1945-58	5,480	15	779	564,000
Bear River near Preston, Idaho	1889-1917	8,500			
	1944-58	4,420	0.6	879	636,400
Cub River near Preston, Idaho	1940-52				
	1955-58	715	11	87.6	63,420
Little Bear River near Paradise, Utah	1938-58	1,830	4	88	63,710
Little Bear River near Hyrum, Utah	1938-58	986	0.2	63.9	46,260
Blacksmith Fork above diversion near Hyrum, Utah	1913-58	1,620	29	126	91,220
Hammond (East Side) Canal near Collinston, Utah	1917-58	182	0	52.3	37,860
Westside Canal near Collinston, Utah	1912-58	748	0	232	168,000
Bear River near Collinston, Utah	1889-1958	11,600	0	1,620	1,171,000
Malad River at Woodruff, Idaho	1938-58	650	15		
Bear River near Corinne, Utah**	1949-57	7,200	86	1,687	1,221,000

* U.S.G.S. Gaging Stations
** Discontinued 1957

Return Flow and Consumptive Use of Irrigation Water

About 483,000 acres of basin land are irrigated from the Bear River and its tributaries. Approximately 12 percent of the land is in Wyoming, 35 percent in Idaho, and 53 percent in Utah. The proportion of the irrigation water which returns to the stream varies over a wide range and depends largely on the definition of the term "return flow." Considering the return flow as that portion of the water that is not lost by evaporation or transpiration, the average quantity of return flow over the Western States is considered to be about one-third of the quantity of water diverted. In some cases irrigation return flow is reused a number of times before the Bear River finally flows into the Bear River Bay.

Annual consumptive use of irrigation water in the Bear River Basin, exclusive of effective precipitation, averages about 1.5 acre-feet per acre of irrigated land. Assuming 90 percent of the irrigable land is irrigated annually, consumptive use of Bear River water for irrigation amounts to approximately 652,000 acre-feet annually.

Domestic and Industrial Wastes

Domestic wastes with partial or no treatment from 14 communities are discharged to the Bear River and its tributaries. Municipalities in the basin with populations ranging from 100 to 16,832 contribute a total biochemical oxygen demand population equivalent[1/] of approximately 36,400. Domestic sources of pollution are shown in Table 5. Only 4 of the 14 communities listed have been provided with satisfactory treatment facilities.

Industrial wastes with a population equivalent of about 931,200 are discharged to the Bear River and its tributaries from 23 industries. These wastes receive practically no treatment prior to their discharge. The sugar factories that discharge the greatest volume of wastes with a high bacterial content, usually operate during the beet harvesting season or generally during October and November in the Bear River Basin. Industrial sources of pollution are listed in Table 6.

1/ Biochemical oxygen demand population equivalent - (1) The calculated population which would normally contribute the same amount of biochemical oxygen demand (B.O.D.) per day. A common base is 0.167 pound of 5-day B.O.D. per capita per day. (2) For an industrial waste, the estimated number of people contributing sewage equal in strength to a unit volume of the waste or to some other unit involved in producing or manufacturing a particular commodity.

Table 5
Municipal waste disposal facilities
Bear River Basin[1]/

Community	1950 population	Estimated population served	Average daily flow (MGD)	Population equivalent discharged to watercourse[2]/	Treatment	Discharge to
Evanston, Wyo.	3,863	3,800		2,000	Primary	Bear River
Montpelier, Idaho	2,682	2,000		2,000	None	Montpelier Creek to Bear River
Paris, Idaho	774	600	0.6	450	Septic tanks	Paris Canyon to Bear Lake outlet
Soda Springs, Idaho	1,329	1,000		800	None	Little Spring Creek to Bear River
Conda, Idaho	300	300	0.15		Septic tank and lagoons	To land
Preston, Idaho	4,045	3,200	0.5	2,600	Primary	Worm Creek to Cub River
Malad City, Idaho	2,715	2,000	1.6	2,000	Primary	Deep Creek to Malad River
Lewiston, Utah	1,533	500	X	500	None	Cub River
Logan, Utah	16,832	16,802	X	22,000	None	Logan River
Wellsville, Utah	1,241	500	X	500	None	Little Bear River
Garland, Utah	1,008	900	X	900	None	Malad River
Tremonton, Utah	1,662	1,600	X	1,600	Septic tank	Malad River
Bear River High School		1,204	X	550	X	Malad River
Corinne, Utah	425	500	X	500	None	Bear River

1/ All communities in above table are listed as they occur in sequence in downstream order. An "X" in the listings indicates that the data called for are not available.

2/ Includes industrial wastes discharged into municipal sewerage systems.

Table 6
Industrial waste disposal facilities
Bear River Basin

Industry	Industry	Community	Average daily flow (MGD)	Population equivalent discharged to watercourse	Treatment	Discharge to
San Francisco Chemical Co.	Ore concentration	Leefe, Wyo.	0.3	-	Lagoon	None
Minerals of Utah, Inc.[2]	Ore concentration	Laketown, Utah	0.1	-	Lagoons	-
Bear Lake Dairymen's Association	Food	Paris, Idaho	0.012	610	Septic tank	Drainage ditch
Central Farmers Fertilizer Co.	Chemicals	Georgetown, Idaho	-	-	-	Bear River
Monsanto Chemical Co.	Chemicals	Soda Springs, Idaho	-	-	Lagoons	Soda Creek
Grace Cheese Factory	Food	Grace, Idaho	-	-	None	Bear River
Thatcher Cheese Factory	Food	Thatcher, Idaho	-	-	None	Bear River
Franklin County Sugar Co.	Food	Whitney, Idaho	4.4	260,000	Lagoons	Worm Creek to Cub River
California Packing Co.	Food	Franklin, Idaho	0.21	17,800	Fine screens	Cub River
Amalgamated Sugar Co.	Food	Lewiston, Utah	17.0	400,000	Lagoons	Cub River
Gilt Edge Flour Mill	Food	Richmond, Utah	-	-	-	Cub River
Sego Milk Products Co.	Food	Richmond, Utah	-	2,260	None	Bear River
Cache Valley Dairy Association, Rocky Mountain Dairy Products Co.	Food	Amalga, Utah	0.65	7,100	None	Bear River
California Packing Co.	Food	Smithfield, Utah	-	35,200	Fine screens	Irrigation ditch
California Packing Co.	Food	Hyrum, Utah	-	1,050	None	Drainage ditch
E. A. Miller & Sons Packing Co.	Food	Hyrum, Utah	0.4	3,100	None (Blood collected)	Drainage ditch
Tri-Miller Packing Co.	Food	Hyrum, Utah	0.15	1,700	Septic tank (Blood collected)	Drainage ditch
Valley Rendering Co.[1]	Food	Hyrum, Utah	-	1,000	-	Drainage ditch
Morning Milk Co.	Food	Wellsville, Utah	0.14	850	-	Drainage ditch
Utah By-Products Co.	Food	Logan, Utah	-	150	Septic tank	Blacksmith Fork
Utah-Idaho Sugar Co.	Food	Garland, Utah	9.1	200,000	Screens, Lagoon	Malad River
Utah By-Products Co.[2]	Food	Garland, Utah	-	130	None	Malad River
Allen Meat Co.[2]	Food	Tremonton, Utah	-	250	None	Malad River

1/ Plant under construction on April 24, expected to be in operation by June 1, 1959.
2/ No information on these waste sources at this time.

Survey Methods

Stream Sampling Stations

Twelve sampling stations were established on the Lower Bear River system between the Utah-Idaho border and the outlet into Bear River Bay of Great Salt Lake. These stations were established on the main stem above and below each major tributary and above the mouth of each tributary involved as a basis for determining if the chemical and bacteriological quality of the water at various points would be suitable primarily for future municipal and industrial use. Descriptions of the sampling stations, and laboratory analysis for each, appear in Appendix C. The locations of the sampling stations are shown on Map 2, page 14.

Sampling Schedule and Procedures

Samples for chemical analysis and bacteriological examination were collected at monthly intervals from July 1958 through June 1959 and semi-monthly intervals from July through September 1959. Not all 12 stations, however, were in operation during the entire sampling period. The samples were collected at or near points where gaging stations were maintained for measurement of water discharge. They were collected at approximately midstream and about middepth from bridge crossings.

For each sample taken the sample collector noted the date, time, temperature, and reading of a staff gage located in the stream at the gaging stations listed in Exhibits I and II, Appendix A. Dissolved oxygen samples were fixed in the field immediately after collected and titrated in the laboratory.

Laboratory Analyses

All chemical analyses and bacteriological examinations were conducted at the Salt Lake City laboratory, operated by the Utah State Department of Health. Samples were collected each morning at intervals stated above and delivered to the laboratory the same day of collection.

The laboratory determinations listed below were made on all stream samples.

1. Chemical analyses--Hydrogen-ion concentration (pH), free carbon dioxide (CO_2), silica (SiO_2), total iron (Fe), calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), bicarbonate (HCO_3), carbonate (CO_3), chloride (Cl), total nitrogen as nitrate (NO_3), sulfate (SO_4), fluoride (F), alkalinity (as $CaCO_3$), hardness (as $CaCO_3$), total dissolved solids and boron (B).

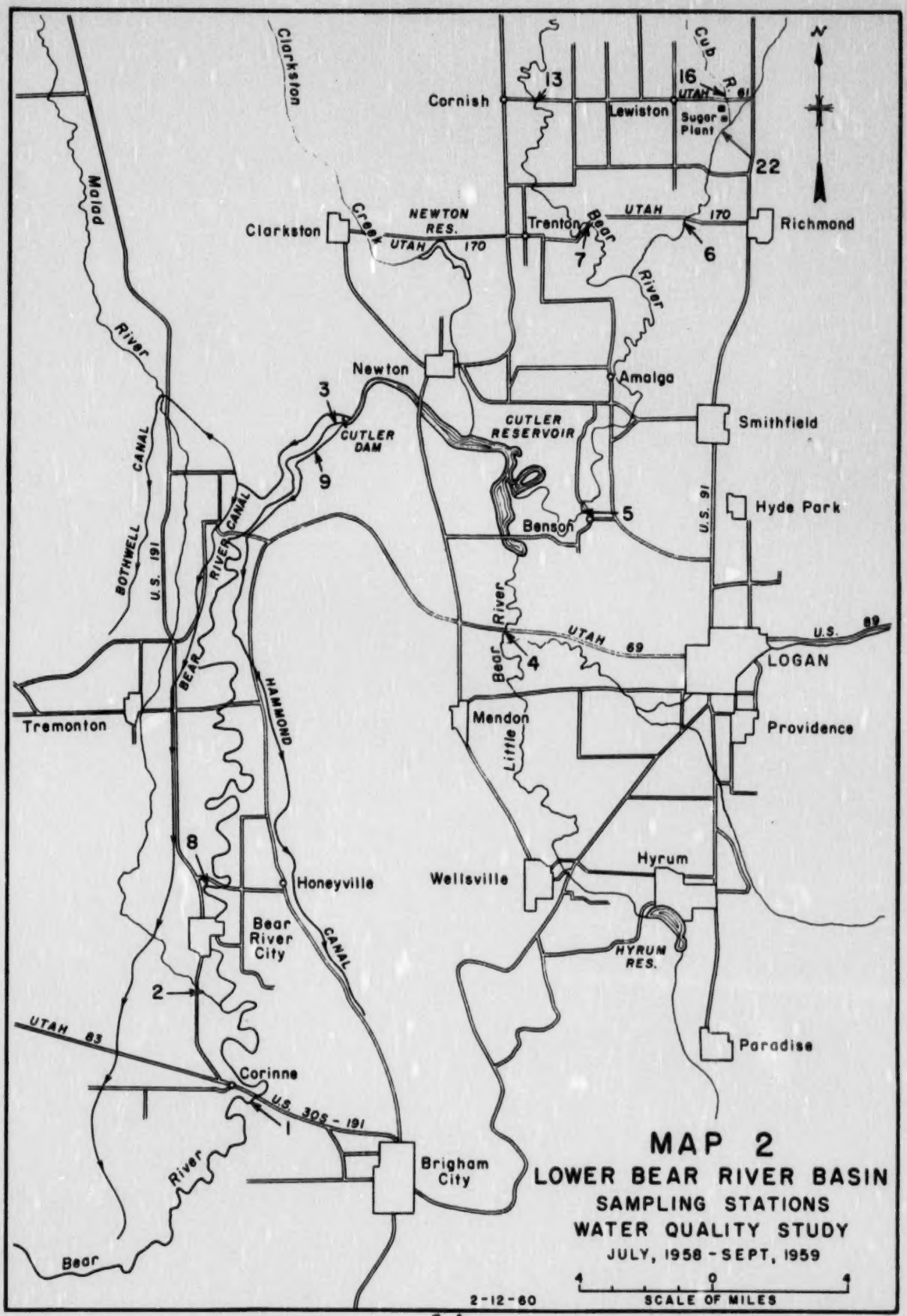
Free carbon dioxide was determined by reference to the equilibrium table using the hydrogen-ion concentration and alkalinity. The total iron test is for iron only and does not include both iron and manganese.

2. Bacteriological examinations.--Coliform organisms as most probable numbers (MPN).

3. Dissolved oxygen and biochemical oxygen demand.--Dissolved oxygen and biochemical oxygen demand determinations were made on semimonthly samples collected July through September 1959. Dissolved oxygen samples were fixed in the field immediately after sample was collected.

Flow Measurements

All streamflow data with the exception of data for the station on the Little Bear River were collected by a representative of the Logan Development Office, Bureau of Reclamation, Region 4, Logan, Utah. Flow records of the Little Bear River were furnished by J. A. Ward, Consulting Engineer, who is under contract to the State Department of Health to collect streamflow and quality data in the vicinity of Logan.


Clarkston
Cornish
Lewiston
Sugar Plant
Cub R.
UTAH 61
13
16
22
N
Malad River
Clarkston Creek
NEWTON RES.
UTAH 170
Trenton
Bear River
UTAH 170
Richmond
7
6
Newton
Amalga
3
CUTLER DAM
CUTLER RESERVOIR
Smithfield
9
BOTHWELL CANAL
U.S. 191
RIVER CANAL
Benson
5
U.S. 91
Hyde Park
Bear River
UTAH 69
U.S. 89
4
LOGAN
Tremonton
BEAR
HAMMOND
Mendon
Little
Providence
8
Honeyville
Wellsville
Hyrum
Bear River City
CANAL
HYRUN RES.
2
UTAH 83
Paradise
Corinne
U.S. 30S - 191
1
Brigham City
River
Bear
MAP 2
LOWER BEAR RIVER BASIN
SAMPLING STATIONS
WATER QUALITY STUDY
JULY, 1958 - SEPT, 1959
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Interpretation of Chemical and Bacteriological Results

Domestic Water

Proper interpretation and evaluation of chemical and bacteriological results require a general knowledge of limiting water quality requirements. In this connection the Public Health Service Drinking Water Standards recommends the maximum limits of chemical constituents as follows:

1.	Fluoride	1.5	milligrams per liter
2.	Copper	3.0	milligrams per liter
3.	Iron and manganese together	0.3	milligrams per liter
4.	Magnesium	125	milligrams per liter
5.	Zinc	15	milligrams per liter
6.	Chlorides	250	milligrams per liter
7.	Sulfates	250	milligrams per liter
8.	Total solids	500	milligrams per liter*
	* If no other water available	1,000	milligrams per liter

In addition to chemical standards listed above, water quality standards pertaining to bacteriological characteristics are also used to measure the water quality for human consumption.

Bacteriological standards delimit the density of coliform bacteria in the water and in general imply that the water at the consumers' tap must not contain more than a single coliform organism in 100 milliliters. The coliform group of bacteria has as one of its primary habitats the intestinal tract of human beings. Hence the presence in water of members of the coliform group is an indicator of the potential presence of other organisms that originate in the human intestinal tract.

For the purpose of classification with respect to treatment requirements, water acceptable for treatment may be divided into four groups. For practical purposes coliform bacteria content of the raw water can be expressed in terms of "most probable numbers" (MPN). The Public Health Service Manual of recommended water sanitation practice establishes the following groups.

Group 1. Water Requiring no Treatment. This group is limited to underground waters not subject to any possibility of contamination, and meeting the chemical, physical, and bacteriological requirements established for a potable water supply as shown by satisfactory, regular, and frequent sanitary inspections and laboratory tests.

Group 2. Waters Requiring Simple Chlorination, or its Equivalent. This group includes both underground and surface waters subject to a low degree of contamination, and meeting the chemical and physical requirements for a potable water supply. The coliform bacterial content should not average more than 50 per 100 milliliters in any month.

Group 3. Waters Requiring Complete Treatment Including Coagulation, Sedimentation, Filtration, and Continuous Postchlorination, or its Equivalent. This group includes all waters requiring filtration treatment for turbidity and color removal; waters of high or variable chlorine demand; and waters polluted by sewage to such an extent as to be inadmissible to groups 1 and 2, but containing numbers of coliform bacteria averaging not more than 5,000 per 100 milliliters in any one month and exceeding this number in not more than 20 percent of the samples examined in any one month.

Group 4. Waters Requiring Auxiliary Treatment in Addition to Complete Filtration and Postchlorination. This group includes waters meeting the requirements of group 3 with respect to the limiting monthly average coliform numbers, but showing numbers of coliform bacteria exceeding 5,000 per 100 milliliters in more than 20 percent of the samples examined during any one month and not exceeding 20,000 per 100 milliliters in more than 5 percent of the samples examined during one month.

The Utah Water Pollution Control Board has established standards of purity and regulations for classification of the surface waters of the State. The five classifications are:

Class "A" waters shall be so protected against pollution as to be suitable at all times without treatment for domestic water supplies, irrigation, stock watering, fish and wildlife propagation, recreation, as a source for industrial supplies, and for other uses as may be determined by the board.

Class "B" waters shall be so protected against pollution as to be suitable at all times for domestic supplies which are treated before use by disinfection only. Class "B" waters shall be suitable without treatment for irrigation, stock watering, fish and wildlife propagation, recreation, as a source for industrial supplies, and for other uses as may be determined by the board.

Class "C" waters shall be so protected against pollution as to be suitable at all times for domestic water supplies which are treated before use by coagulation, sedimentation, filtration, and disinfection. Class "C" waters shall be suitable without treatment for irrigation, stock watering, fish and wildlife propagation, recreation (except swimming), as a source for industrial supplies, and for other uses, as may be determined by the board.

Class "D" waters shall be so protected against pollution as to be suitable at all times for general irrigation, but not for irrigation of lawns, recreational areas, pastures used for dairy cattle, root crops or any low growing crops produced for human consumption. Such waters shall be suitable also as a source for industrial supplies and for other uses as may be determined by the board.

Class "E" waters shall be protected against ruch pollution as may result in nuisances. They shall have no beneficial uses.

Class "A" waters conceivably might include exceptional surface waters free of any possible contamination and further protected by storage. As a general rule it is not safe to admit any surface water to a public supply without chlorination as a minimum safeguarding treatment. Surface waters, Class "B," that may be rendered safe by disinfection only are generally only found in the headwaters of a river system or in inaccessible mountainous areas where recreation and migratory travel does not occur. In general, surface waters draining and flowing through inhabited areas will, at best, be Class "C" waters.

The regulations and standards adopted by the Utah Water Pollution Control Board for Class "C," "D," and "E" waters are:

No person shall discharge into Class "C" waters any wastes

(1) which result in chemical characteristics of said waters exceeding the limits prescribed by U. S. Public Health Service Drinking Water Standards as of February 6, 1946, or

(2) which result in chemical characteristics of said waters exceeding the recommendations for irrigation water quality as outlined in Chapter 5 of the U. S. Department of Agriculture "Agriculture Handbook No. 60," issued February 1954, or

(3) which result in a monthly arithmetical average "most probable number" (MPN) of coliform organisms in said waters exceeding 5,000 per 100 milliliters; or in an MPN exceeding this number in more than 20% of the samples collected during any month; or in an MPN exceeding 20,000 per 100 milliliters in more than 5% of such samples, or

(4) which result in a monthly arithmetical average biochemical oxygen demand (BOD) in said waters exceeding 5 parts per million (p.p.m.); or in a BOD exceeding this amount in more than 20% of the samples collected in any month; or in a BOD exceeding 10 p.p.m. in more than 5% of such samples, or

(5) which result in any slicks, floating solids, suspended solids or sludge deposits in said waters which are readily visible, or which result in an appreciable change in color of said waters, or

(6) which result in a pH of said waters lower than 5.0 or greater than 9.0, or

(7) which contain any toxic wastes, phenols, or other deleterious substances in such concentrations or at such temperatures as will render said waters injurious to fish life and waterfowl, or unsafe or unsuitable as sources of water supply for domestic use, food processing or industrial use, or unsuitable for agricultural purposes, stock watering, or recreation (except swimming).

No person shall discharge into Class "D" waters any wastes

(1) which result in chemical characteristics of said waters exceeding the limits prescribed by U. S. Public Health Service Drinking Water Standards as of February 6, 1946, or

(2) which result in chemical characteristics of said waters exceeding the recommendations for irrigation water quality as outlined in Chapter 5 of U. S. Department of Agriculture "Agriculture Handbook No. 60," issued February 1954, or

(3) which result in a monthly arithmetical average "most probable number" (MPN) of coliform organisms in said waters exceeding 5,000 per 100 milliliters; or in an MPN exceeding this number in more than 20% of samples collected during any month; or in an MPN exceeding 20,000 per 100 milliliters in more than 5% of such samples, or

(4) which result in a monthly arithmetical average biochemical oxygen demand (BOD) in said waters exceeding 25 parts per million (p.p.m.); or in a BOD exceeding this amount in more than 20% of the samples collected in any month; or in a BOD exceeding 50 p.p.m. in more than 5% of such samples, or

(5) which result in any slicks, floating solids, suspended solids, or sludge deposits in said waters which are readily visible, or which result in an appreciable change in color of said waters, or

(6) which result in a pH of said waters lower than 5.0 or greater than 9.0, or

(7) which contain any toxic wastes, phenols, or other deleterious substances in such concentrations or at such temperatures as will render said waters unsuitable for the uses designated in the introductory paragraph of this section.

No person shall discharge into Class "E" waters any wastes which will create a condition constituting or resulting in a nuisance. The board may direct that such waters be suitably isolated by closed conduit, approved fencing, or other means.

Industrial Water Quality Requirements

Chemical quality requirements for a limited number of industries and processes commonly encountered are listed in Table 7.

TABLE 7
WATER QUALITY TOLERANCES FOR INDUSTRIAL APPLICATIONS[1]/
ALLOWABLE LIMITS IN PARTS PER MILLION

Industry	Turbidity	Color	Odor	Hardness	Alkalinity as $CaCO_3$	pH	Total solids	Ca	Fe	Mn	Fe+Mn	SiO_2	F	CO_3	HCO_3	OH	$CaSO_4$	Na_2SO_4 to Na_2SO_3 ratio	General[2]/
Air conditioning[3]/									0.5	0.5	0.5								A, B
Baking	10	10		(4)					0.2	0.2	0.2								C
Boiler feed																			
0-150 psi	20	80		75		8.0+	3,000-1,000					40		200	50	50		1 to 1	
150-250 psi	10	40		40		8.5+	2,500-500					20		100	30	40	4	2 to 1	
250 psi and up	5	5		8		9.0+	1,500-100					5		40	5	30		3 to 1	
Brewing[5]/																			
Light	10		low		75	6.5-7.0	500	100-200	0.1	0.1	0.1		1				100-200		C, D
Dark	10		low		150	7.0	1,000	200-500	0.1	0.1	0.1		1				200-500		C, D
Canning																			
Legumes	10		low	25-75					0.2	0.2	0.2								C
General	10		low						0.2	0.2	0.2		1						C
Carbonated beverages[6]/	2	10	0	250	50		850		0.2	0.2	0.3		0.2						C
Confectionary			low			(7)	100		0.2	0.2	0.2								C
Cooling[8]/	50			50					0.5	0.5	0.5								A, B
Food, general	10		low						0.2	0.2	0.2								C
Ice (raw water)[9]/	1-5	5			30-50		300		0.2	0.2	0.2	10							C
Laundering				50					0.2	0.2	0.2								
Plastic																			
Clear undercolored	2	2					200		0.02	0.02	0.02								
Paper and pulp[10]/																			
Groundwood	50	20		180					1.0	0.5	1.0								
Kraft pulp	25	15		100			300		0.2	0.1	0.2								A
Soda and sulfite	15	10		100			200		0.1	0.05	0.1								
Light paper																			
HL-grade	5	5		50			200		0.1	0.05	0.1								
Tanning[11]/	20	10-100		50-135	135	8.0			0.2	0.2	0.2								B
Textiles																			
General	5	20		20					0.25	0.25									
Dyeing[12]/	5	5-10		20					0.25	0.25	0.25								
Wool scouring[13]/		70		20					1.00	1.00	1.00								
Cotton bandage[13]/	5	5	low	20					0.2	0.2	0.2								

1/ American Water Works Association - 1950.

2/ A - No corrosiveness; B - No slime formation; C - Conformance to USPHS drinking water standards necessary; D - NACl 275 ppm.

3/ Waters with algae and hydrogen sulfide odors are most unsuitable for air conditioning.

4/ Some hardness desirable.

5/ Water for distilling must meet the same general requirements as for brewing (gin and spirits mashing water of light beer quality; whiskey mashing water of dark beer quality).

6/ Clear, odorless, sterile water for syrup and carbonization. Water consistent in character. Most high quality filtered municipal water not satisfactory for beverages.

7/ Hard candy requires pH of 7.0 or greater, as low value favors inversion of sucrose, causing sticky product.

8/ Control of corrosiveness is necessary as is also control of organisms, such as sulfer and iron bacteria, which tend to form slimes.

9/ $Ca(HCO_3)_2$ particularly troublesome. $Mg(HCO_3)_2$ tends to greenish color. CO_2 assists to prevent cracking. Sulfates and chlorides of Ca, Mg, Na should each be less than 300 ppm (white butts).

10/ Uniformity of composition and temperature desirable. Iron objectionable as cellulose absorbs iron from dilute solution. Manganese very objectionable, clogs pipelines and is oxidized to permanganate by chlorine, causing reddish color.

11/ Excessive iron, manganese or turbidity creates spots and discoloration in tanning hides and leather goods.

12/ Constant composition.

13/ Calcium magnesium, iron, manganese, suspended matter and soluble organic matter may be objectionable.

Laboratory Results

Results of the physical, chemical, and bacteriological examinations are summarized in Table 8 and briefly discussed in the following sections. The chemical constitutents not included in this table are within the limiting requirements of the drinking water standards. The results are presented for the various sampling stations in the stations' downstream order on the river system.

Stream discharge, chemical constitutents exceeding recommended maximum levels, temperatures, bacteriological, dissolved oxygen and biochemical oxygen demand by individual stations are shown graphically in Appendix B. The results for each individual sample collected during the sampling period appear in Appendix C, Tables C-I through C-V.

Station 13--Bear River East of Cornish

Results of samples collected from Station 13 on the Bear River about one mile east of Cornish, Utah, river mile 70, from July through September 1959, show that iron, hardness, chloride, and total dissolved solids slightly exceed the desirable limits. Bear River in this area, however, is considered a satisfactory source of raw water for domestic and industrial purposes. Total iron ranged from 0.8 to 1.2 mg/l, hardness from 313 to 378 mg/l, chlorides from 82 to 281 mg/l, and total dissolved solids from 542 to 904 mg/l (Figure 1).

Although excessive iron and hardness are not desirable in water for domestic and industrial use, these constituents can be removed by conventional water treatment methods.

Bacterial pollution at Station 13 ranged from 140 to 9,300 coliforms per 100 milliliters for an average of 2,105. Only one sample of the six collected during the 3-month sampling period exceeded the limit of 5,000 per 100 milliliters for "Class C" waters (Figure 2). Although these results are not excessive, the bacterial pollution would be reduced by construction of adequate sewage treatment facilities with chlorination of the treatment plant effluent for communities upstream from this station. Adequate sewage treatment facilities for industry discharging organic wastes to the river upstream from this station would also decrease the bacterial pollution.

The dissolved oxygen content of the river at Station 13 ranged from 5.6 to 8.5 and averaged 6.8 mg/l. The percent saturation for dissolved oxygen ranged from 72 to 96. The biochemical oxygen demand ranged from 1.1 to 3.2 mg/l and averaged about 2.3 mg/l (Figure 3) and 7,340 pounds daily. Initiation of chlorination facilities at upstream waste disposal plants should reduce the biochemical oxygen demand at this station.

Station 7--Bear River Above Mouth of Cub River

Samples collected from Station 7 on the Bear River, above the mouth of the Cub River, river mile 64, from July 1958 through June 1959, show

TABLE 8
SUMMARY OF PHYSICAL, BACTERIOLOGICAL, AND CHEMICAL QUALITY
LOWER BEAR RIVER

	Sampling Station[1] and Period	Months of Record		Discharge cfs	Temperature °F	Dissolved[2] Oxygen	Biochemical Oxygen Demand[2] BOD	MPN Coliform per 100 ml.	Total Iron Fe	Magnesium Mg	Sodium Na	Chloride Cl	Sulfate SO_4	Hardness as $CaCO_3$[3]	Total Dissolved Solids
			Concentrations in Milligrams per Liter												
13	Bear River east of Cornish		Max.	940	69	8.5	3.2	9,300	1.2	56	197	281	84	378	904
			Min.	390	56	5.6	1.1	140	0.8	48	69	82	71	313	542
	July - Sept. 1959	3	MES[4]					1	3	0		1	0	3	3
7	Bear River above mouth of Cub River		Max.	1,088	72			23,000	3.7	59	105	138	81	386	652
			Min.	472	34			73	0.36	30	50	82	13	298	504
	July 1958 - June 1959	12	MES					1	12	0		0	0	12	12
16	Cub River above Amalgamated Sugar Co.		Max.	12	70	5.5	8.6	24,000	4.0	34	65	60	43	294	494
			Min.	4	52	0.5	2.3	1,400	0.9	30	24	18	10	230	365
	July - Sept. 1959	3	MES					2	3	0		0	0	3	0
22	Cub River below Amalgamated Sugar Co.		Max.	25	62	9.5	4.9	4,300	2.0	37	30	40	42	280	370
			Min.	10	49	6.0	1.3	290	0.4	14	20	25	9	236	293
	July - Sept. 1959	3	MES					0	3	0		0	0	3	0
6	Cub River west of Richmond		Max.	445	70	8.45	7.2	2,300,000+	6.8	41	35	48	30	448	877
			Min.	12	34	5.55	1.4	43	0.57	9	7	8	5	145	201
	July 1958 - Sept. 1959	15	MES					7	15	0		0	0	13	2
5	Bear River west of Smithfield		Max.	1,250	73	7.7	6.3	230,000	5.0	58	86	116	86	372	610
			Min.	403	35	5.8	1.9	73	0.7	26	15	45	35	238	350
	July 1958 - Sept. 1959	15	MES					6	15	0		0	0	15	11
4	Little Bear River below mouth of Logan River		Max.	394	75	8.3	6.0	43,000	12.0	44	26	28	44	284	385
			Min.	73	37	5.5	1.0	230	0.52	8	8	12	16	209	255
	July 1958 - Sept. 1959	15	MES					1	15	0		0	0	15	0
9	Hammond Canal below Cutler Dam		Max.	167	76			1,400	1.63	56	72	85	76	354	593
			Min.	60	58			93	0.79	23	48	58	32	237	398
	May - Sept. 1959	5	MES					0	5	0		0	0	5	3
3	Bear River just below Cutler Dam		Max.	2,585	76	9.3	3.5	9,300	2.3	54	190	290	74	347	865
			Min.	20	35	6.8	1.3	93	0.41	21	31	41	27	231	330
	July 1958 - Sept. 1959	15	MES					2	15	0		2	0	15	9
8	Bear River west of Honeyville		Max.	1,690	77			23,000	3.65	59	213	329	78	364	993
			Min.	30	46			23	0.70	29	31	45	35	245	353
	March - Sept. 1959	7	MES					1	7	0		3	0	7	5
2	Malad River above confluence of Bear		Max.	110	75			2,300,000+	17.0	84	920	1,283	285	594	3,004
			Min.	6	36			2,300	1.3	26	180	217	98	324	854
	July 1958 - Sept. 1959	15	MES					12	15	0		15	1	15	15
1	Bear River at Corinne		Max.	1,813	81		9.2	46,000	2.78	59	800	1,234	103	409	2,568
			Min.	13.7	35		2.8	43	0.50	24	69	113	55	260	430
	July 1958 - Sept. 1959	15	MES					4	15	0		9	0	15	14

1/ Sampling stations listed as they occur in sequence downstream. More detailed descriptions appear in Appendix C.
2/ Sampled July - September 1959 only.
3/ Limiting value of 200 milligrams per liter adopted.
4/ MES = Number of months that the drinking water standards were exceeded during sample period. For MPN column the 3d line entry is the number of months coliform counts exceeded Utah Water Polution Control Board standards for class "C" water.

that the concentrations of iron, hardness, and total dissolved solids slightly exceed the desirable limits. The Bear River in this area, however, is considered a satisfactory source of raw water for domestic and industrial purposes. Excess hardness and iron could be removed by conventional water treatment methods. During the entire 12-month sampling period total iron ranged from 0.36 to 3.7 mg/l, hardness from 298 to 386 mg/l, and total dissolved solids from 504 to 652 (Figure 1).

Bacterial pollution at Station 7 ranged from 73 to 23,000 coliforms per 100 milliliters for an average of 2,341. The bacterial standards for "Class C" water were exceeded during one month of the sampling period (Figure 2). The bacterial pollution would be reduced with construction of adequate domestic and industrial waste treatment facilities, with chlorination of the effluent, at upstream sources of pollution.

Station 16--Cub River Above Amalgamated Sugar Company

Results of samples collected from the Cub River about 1½ miles east of Lewiston, Utah, river mile 6, from July through September 1959, show that the concentrations of iron and hardness exceeded the desirable limits for potable water 100 percent of the time. Iron ranged from 0.9 to 4.0 mg/l and hardness from 230 to 294 mg/l (Figure 4). These constitutents, however, may be removed by conventional water treatment methods for domestic and industrial use. Total dissolved solids were within the recommended limits, ranging from 365 to 494 mg/l. Appendix C, Table C-V, shows that total dissolved solids in 67 percent of the samples ranged over 400 mg/l.

Bacterial pollution at Station 16 ranged from 1,400 to 24,000 coliforms per 100 milliliters for an average of 14,000. The bacterial requirements for "Class C" water were exceeded 50 percent of the time (Figure 5). The bacterial count at Station 16 is influenced by the effluent of the Preston, Idaho, primary sewage treatment plant, about 8 miles upstream, having an estimated population equivalent of 2,600. The bacterial count is also influenced by discharge of industrial wastes from the Franklin County Sugar Company at Whitney, Idaho, and the California Packing Company at Franklin, Idaho. Although bacteriological samples were not collected from either of these industries, the results indicate that the wastes from the California Packing Company were apparently largely responsible for the bacterial counts at the station as the sampling period covers the seasonal operating period of this plant. Treatment facilities at the packing plant consist of fine screens only and the wastes discharged to the Cub River have an estimated population equivalent of 17,800 (Table 6). The sugar campaign generally occurs during October and November. Although the bacterial counts at Station 16 are not excessive, the bacterial pollution would be reduced to a considerable extent by the initiation of improved sewage and industrial waste treatment practices above this station. The effect of the sugar beet campaigns on bacterial pollution was evident at Station 6 on the Cub River during October and November 1958, when coliform counts of 2,300,000+ were obtained. (Appendix C, Table C-IV.)

The dissolved oxygen content of the river at Station 16 ranged from 0.5 to 5.5 and averaged 2.15 mg/l. The percent saturation for dissolved oxygen ranged from 7 to 59. The biochemical oxygen demand ranged from 2.3 to 8.6 and averaged 5.47 mg/l and 222 pounds daily (Figure 6). The biochemical oxygen demand requirement of 5 mg/l or less for "Class C" water set by the Utah Water Pollution Control Board was exceeded in 67 percent of the samples collected. The sampling period for biochemical oxygen demand did not extend into the sugar campaign period so the effect of wastes from the Franklin County Sugar Company in Idaho having an estimated population equivalent of 260,000 was not evident. Improved sewage and industrial waste treatment facilities upstream will reduce the biochemical oxygen demand of this station.

Station 22--Cub River Below Amalgamated Sugar Company

In samples collected from the Cub River below the Amalgamated Sugar Company, river mile 4, the concentrations of iron and hardness exceeded the desirable limits during the entire sampling period, July through September 1959. Iron ranged from 0.4 to 2.0 mg/l and hardness from 236 to 280 mg/l (Figure 7). Total dissolved solids at this station were the lowest experienced at any sampling station, ranging from 293 to 370 mg/l. Appendix C, Table C-IV, shows, however, that during the sugar campaigns the concentrations of hardness and total solids increased considerably.

Bacterial pollution at Station 22 ranged from 290 to 4,300 coliforms per 100 milliliters for an average of 1,363 (Figure 8). These results are all within the limit of 5,000 coliforms per 100 milliliters for "Class C" water, but they do not reflect the bacterial pollution from sugar plant wastes. Installation of adequate sewage and waste disposal at upstream sources of pollution, plus chlorination of waste effluents, would reduce the organic pollution load at the station.

The dissolved oxygen content at Station 22 ranged from 6.0 to 9.5 and averaged 7.0 mg/l. The percent saturation of dissolved oxygen ranged from 67 to 113. The biochemical oxygen demand ranged from 1.3 to 4.9 and averaged 2.45 mg/l and 205 pounds daily (Figure 9).

Station 6--Cub River Above Confluence of the Bear River West of Richmond

Results of samples collected from the Cub River west of Richmond and just above the confluence of the Bear River, river mile 1, from July 1958 through September 1959, show the concentrations of certain chemical constituents exceeded the desirable limits. Iron ranged from 0.57 to 6.8 mg/l, hardness from 145 to 448 mg/l, and total dissolved solids from 201 to 877 mg/l (Figure 10). The concentration of iron exceeded the limits during the entire sampling period, hardness exceeded limits about 87 percent of the time, and total dissolved solids exceeded limits about 13 percent of the time.

Bacterial pollution at Station 6 ranged from 43 to 2,300,000+ coliforms per 100 milliliters for an average of 263,500+ (Figure 11). The

high bacterial counts of 2,300,000+ occurred in October and November whereas the count for the remaining 13 months of the sampling period averaged 8,937. Although bacteriological samples of the wastes from the Franklin County and Amalgamated Sugar Companies were not collected during the sugar campaigns, the results indicate that these wastes were apparently responsible for the unusually high counts noted during October and November 1958 when the refineries were operating. High counts were also noted at Station 2 on the Malad River below the Utah-Idaho Sugar Company during October and November 1958. It is possible that sugar plant wastes may influence the bacterial pollution by serving as a nutrient for the organisms. Adequate treatment of sugar refinery wastes before they are discharged into the river would reduce the bacterial pollution of the river. This, in conjunction with improved sewage and industrial waste treatment practices at upstream sources of pollution, would reduce the bacterial pollution to that allowable for "Class C" water.

The dissolved oxygen content of the river at Station 6 ranged from 5.55 to 8.45 and averaged 6.47 mg/l. The biochemical oxygen demand ranged from 1.4 to 7.2 and averaged 2.95 mg/l and 310 pounds daily (Figure 12). With an estimated population equivalent for the sugar plant wastes of 400,000, the biochemical oxygen demand at this station during the sugar campaign would be in excess of 65,000 pounds daily.

Station 5--Bear River Above Cutler Reservoir, 3 miles west of Smithfield

Analysis of samples collected from the Bear River, west of Smithfield and above Cutler Reservoir, river mile 52, during the period July 1958 through September 1959, shows certain chemical constituents exceeding the desirable limits. Iron ranged from 0.7 to 5.0 mg/l, hardness from 238 to 372 mg/l, and total dissolved solids from 358 to 610 mg/l (Figure 13). The desirable limits for iron were exceeded during the entire sampling period, hardness exceeded the desirable limits 87 percent of the time, and total dissolved solids exceeded the limits 73 percent of the time. Only one sample showed total solids of less than 495 mg/l. Although dilution of the Bear River by water from the Cub River reduced the overall concentration of hardness and total dissolved solids, the maximum concentration of iron increased over that experienced at Station 7 on the Bear. These concentrations are slightly in excess of the desirable limits for water used for domestic and some industrial purposes. Adequate water treatment methods would reduce the iron and hardness to permissible levels, making water from this station available for domestic use and some industrial uses provided waters with lower total dissolved solids were not available.

Bacterial pollution at Station 5 was high, ranging from 73 to 230,000 coliforms per 100 milliliters for an average of 15,213. This high pollution is apparently attributable to discharge of sugar plant wastes to the Cub River above the station. The average coliform count for the sampling period, exclusive of October, was 2,579. Thirty-three percent of the samples had a coliform count higher than that acceptable for "Class C" water (Figure 14).

The dissolved oxygen content of the river ranged from 5.8 to 7.7 and averaged 6.21 mg/l. The percent saturation of dissolved oxygen ranged from 78 to 86. The biochemical oxygen demand ranged from 1.9 to 6.3 and averaged 3.45 mg/l and 11,500 pounds daily (Figure 15).

Station 4--Little Bear River Below Mouth of Logan River

Results of samples collected from the Little Bear River below the mouth of Logan River, river mile 7, for the period July 1958 through September 1959, show the iron concentrations ranged from 0.52 to 12.0 mg/l, the hardness from 209 to 284 mg/l, and the total dissolved solids from 255 to 385 mg/l (Figure 16). The high iron concentration occurred in the sample obtained in June 1959. Excluding this one sample, the iron ranged from 0.52 to 3.60 and averaged about 1.29 mg/l.

Bacterial pollution at Station 4 ranged from 230 to 43,000 and averaged 4,081 coliforms per 100 milliliters. On the basis of individual samples the coliform limit for "Class C" water was exceeded in March 1959 when the coliform count was 43,000 (Figure 17). Excluding this high number, the coliform count averaged about 1,800 during the sampling period. At the present time the city of Logan discharges raw sewage into the Logan River approximately 10 miles upstream from Station 4.

The dissolved oxygen content of the river at Station 4 ranged from 5.5 to 8.3 and averaged about 6.37 mg/l. The biochemical oxygen demand ranged from 1.0 to 6.0 and averaged about 2.5 mg/l and 1,730 pounds daily (Figure 18). Review of the data in Appendix C, Table C-III, shows that the July-September period is generally the time of low river flows. The percent saturation of oxygen in the river at this station ranged from 66 to 95.

A review of the results presented in Appendix C shows that the Little Bear River is one of the best sources of water for domestic and industrial uses in the Lower Bear River Basin. A further improvement in bacteriological quality will be noted when the city of Logan provides adequate sewage treatment facilities.

Station 9--Hammond Canal

Sample collection at the Hammond Canal diversion from Cutler Reservoir was initiated when an increase in chemical constituents was apparent between Stations 5 and 3 following dilution of the Bear River water by the Little Bear River. Visual observations indicated the possibility of increased chemical constituents occurring between Cutler Dam and Station 3, first station on the Bear River below Cutler Dam.

Results of samples collected at the Hammond Canal station show the iron concentrations ranged from 0.79 to 1.63 mg/l, hardness from 237 to 354 mg/l, and total dissolved solids from 398 to 593 mg/l (Figure 19). Total dissolved solids exceeded the desirable limits 60 percent of the time.

Results for Stations 5 and 3 on the Bear River and the Hammond Canal station for the same period, May-September 1959, are compared in Table 9. The table indicates an improvement in chemical quality of the Bear River water between Stations 5 and 9. Comparison of chemical constituents of Bear River water diverted from Cutler Reservoir to the Hammond Canal to the Bear River at Station 3, just downstream from the Cutler Dam, shows chlorides increasing from an average of 76 to 252 mg/l, sodium from 65 to 168 mg/l, which in turn increases the total dissolved solids from 512 to 784 mg/l.

Table 9
Comparison of water quality of Bear River above, in, and below Cutler Reservoir
(May - September 1959)

	Concentrations in mg/l								
	Station 5 1/			Station 9 1/			Station 3 2/		
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
Total iron	3.6	0.84	1.61	1.63	0.79	1.25	0.96	0.59	0.73
Calcium	71	49	60	65	49	57	72	49	59
Magnesium	58	29	45	56	23	41	54	21	39
Sodium	86	69	88	72	48	65	190	146	168
Potassium	14	8	12	13	8	10	11	9	10
Chlorides	116	82	97	85	58	76	290	216	252
Nitrates	0.65	0.34	0.48	0.48	0.17	0.33	0.44	0.30	0.37
Sulfates	75	47	67	76	32	57	68	35	55
Fluoride	0.58	0.31	0.41	0.23	0.40	0.32	0.65	0.26	0.43
Bicarbonate	399	256	361	388	260	331	369	279	330
Carbonate	5.6	1.7	4.2	6.14	2.85	4.3	5.1	2.7	3.8
Alkalinity	335	280	312	327	236	288	311	233	275
Hardness	365	284	336	354	237	310	343	254	306
Total dissolved solids	610	546	579	593	398	512	865	707	784
Temperature °F	73	56	64	76	58	69	60	76	71
Discharge (cfs)	968	413	605	167	60	145	25	20	22
MPN Coliform/ 100ml.	23,000	430	5,058	1,400	93	601	2,300	93	510
D.O. mg/l	7.7	5.8	3/6.54				9.3	6.8	4/8.2
B.O.D. mg/l	6.3	1.9	3/3.5				3.5	1.3	4/2.37
B.O.D. pounds	33,000	4,250	3/11,450				474	141	4/282

1/ 8 samples
2/ 7 samples
3/ 6 samples
4/ 5 samples

Conventional water treatment processes would reduce the iron and hardness concentrations of the Hammond Canal water to acceptable limits for domestic purposes and for some industrial use. The total dissolved solids exceed the desirable limits for most domestic and industrial water uses but

where a water of better chemical quality is not obtainable this water may be acceptable.

Bacterial pollution at Station 9 ranged from 93 to 1,400 and averaged 601 coliforms per 100 milliliters (Figure 20). The sampling period at this station, however, did not overlap into the sugar campaign periods so the effect of the sugar plant wastes, if any, on bacterial pollution was not noted. In general, this effect should not be of great consequence as this station is about 40 river miles from the sugar plant outlet.

Station 3--Bear River Below Cutler Dam

Table 9 shows greater amounts of some chemical constituents in water at Station 3 than in water diverted from Cutler Reservoir at Station 9. On the basis of the average concentrations shown in Table 9, the chlorides increased from 76 at Station 9 to 252 mg/l at Station 3, sodium increased from 65 to 168 mg/l, and total dissolved solids increased from 512 to 784 mg/l. The increases are explained by the entrance of high mineral waters just below the Cutler Dam. The effect of these mineral waters is greatest during periods of low flow (Table C-II). The concentrations of iron, chlorides, hardness, and total dissolved solids are above the desirable limits (Figure 21) for domestic and industrial purposes.

Bacterial pollution at Station 3 ranged from 93 to 9,300 coliforms per 100 milliliters and averaged 1,474 (Figure 22). The effects of storage and sedimentation in Cutler Reservoir were apparently responsible for the marked reduction in the coliform count between Stations 5 and 3. The two samples collected during October and November were the only samples with the bacterial content exceeding the limits of "Class C" water. The only explanation for this condition appears to be the discharge of wastes from the Franklin County and Amalgamated Sugar Companies.

The dissolved oxygen content of the Bear River at Station 3 during the sampling period ranged from 6.8 to 9.3 mg/l and averaged 8.2. The biochemical oxygen demand ranged from 1.3 to 3.5 and averaged 2.37 mg/l (Figure 23) and 282 pounds daily with an average flow of 22 second-feet. With a flow of 830 second-feet at the time the last sample in September was collected, the biochemical oxygen demand was 3.5 mg/l and 15,700 pounds.

Station 8--Bear River West of Honeyville

Results of samples collected from the Bear River west of Honeyville and about 22 miles below Station 3, river mile 23, from March through September 1959 show certain chemical concentrations exceeding the desirable limits (Figure 24). Iron ranged from 0.7 to 3.65 mg/l. Chlorides ranged from 45 to 329 mg/l exceeding desirable limits about 43 percent of the time. Hardness ranged from 245 to 364 mg/l and total dissolved solids ranged from 353 to 993 mg/l, exceeding the limits about 72 percent of the time. Reference to Appendix C, Table C-II, shows that the high concentration of chlorides and total dissolved solids generally occur during the low flow periods. Bacterial pollution at Station 8 ranged from 23 to 23,000 coliforms per 100 milliliters and averaged 3,300 (Figure 25).

Under the present stream regimen, waters at Station 8 are unsuitable for domestic use and some industrial use in respect to both chemical and bacteriological quality. However, construction of adequate sewage and industrial waste treatment facilities at upstream sources of pollution will reduce the bacterial pollution at the station to the standards established for "Class C" water. Construction of a dam and reservoir near Honeyville, with reservoir operation to regulate streamflow, will improve the chemical quality of the water at Station 8.

Station 2--Malad River Above Confluence With Bear

Mineral springs with an unusually high salt content discharge into the Malad River, reflecting high concentrations of chemical constituents as shown by Table 10. As a result, water from the lower reaches of the Malad River is not suitable for domestic and industrial uses where chemical quality is a factor. (Figure 26.)

Table 10
Chemical constituents--Malad River above mouth

	MC/L			Percent of samples exceeding limits
	Max.	Min.	Avg.	
Iron	17.0	1.3	5.88	100
Sodium	920	180	440	
Chlorides	1,283	217	657	100
Sulfates	285	92	141	5
Hardness	594	324	427	100
Total dissolved solids	3,004	854	1,678	100

The bacterial pollution in the Malad River ranged from 2,300 to 2,300,000+ coliforms per 100 milliliters (Figure 27). Untreated wastes from the Utah-Idaho Sugar Company plant at Garland, Utah, were apparently responsible for the unusually high coliform count noted during October and November 1958.

Station 1--Bear River Near Corinne

Results of samples collected from the Bear River near Corinne below the mouth of the Malad River, river mile 12, show that certain chemical concentrations exceed the desirable limits. Iron concentrations ranged from 0.50 to 2.78 mg/l, sodium from 69 to 800 mg/l, chlorides from 113 to 1,284 mg/l, hardness from 260 to 409 mg/l, and total solids from 488 to 2,568 mg/l (Figure 28). The highly mineralized flow from Salt Creek and the Malad River accounts for the greater share of the increased salt content of the Bear River at this station. Since chemical quality is the controlling factor, water from the Bear River in the vicinity of Corinne is unsuitable for domestic and most industrial uses.

The bacterial pollution at Station 1 ranged from 43 to 46,000 coliforms per 100 milliliters (Figure 29). The biochemical oxygen demand ranged from 2.8 to 9.2 mg/l and averaged 6.6. Requirements for "Class C" water were exceeded in 87 percent of the samples (Figure 30).

Classification of Lower Bear River as a Source of Water Supply

With the present stream regimen, the suitability of the Lower Bear River as a source of water supply for domestic purposes is summarized in Table 11 by sampling stations.

Table 11
Classification of Lower Bear River water as a source of water supply for domestic purposes

	Chemical quality			Bacteriological quality		
Station	Good	Fair	Unsatisfactory	Good	Fair	Unsatisfactory
13 Bear River east of Cornish		1/ X			X	
7 Bear River above mouth Cub River		1/ X			X	
16 Cub River above Amalgamated Sugar Company	X					2/X
22 Cub River below Amalgamated Sugar Company	X					2/X
6 Cub River above mouth		1/X				2/X
5 Bear River west of Smithfield		1/X				2/X
4 Little Bear River below mouth of Logan River	X			3/X		
9 Hammond Canal		1/X		2/X		
3 Bear River just below Cutler Dam			X		X	
8 Bear River west of Honeyville			X		X	
2 Malad River near mouth			X			4/X
1 Bear River at Corinne			X			X

1/ Total dissolved solids exceed 500 mg/l, but are less than 1,000 mg/l.
2/ Bacterial quality will deteriorate when sugar plant is operating.
3/ Bacterial quality should improve with construction and operation of adequate sewage treatment practices for city of Logan.
4/ Affected by discharges of sugar plant wastes.

It is apparent from Table 11 that in the Lower Bear River system the Little Bear River is the most desirable source of water supply for domestic and industrial purposes. Waters of the Bear River east of Cornish, river mile 70, and above the mouth of the Cub River, river mile 64, may be considered as satisfactory sources of raw water supply for domestic purposes and most industrial uses, but their total dissolved solids are slightly

above the desirable limits. Construction of adequate sewage and industrial wastes treatment facilities for municipalities and industries on the Cub River and its tributaries would make the Cub River a satisfactory source of water.

This study indicates that the Bear River water from Cutler Dam to the Utah-Idaho border would be satisfactory for domestic purposes and most industrial uses if concentrations for total dissolved solids that are slightly in excess of the desirable limits were accepted and if adequate sewage and industrial waste facilities were constructed at upstream sources of pollution. Adequate water treatment facilities would reduce the iron and hardness concentrations to within the desirable limits of 0.3 and 200 mg/l, respectively.

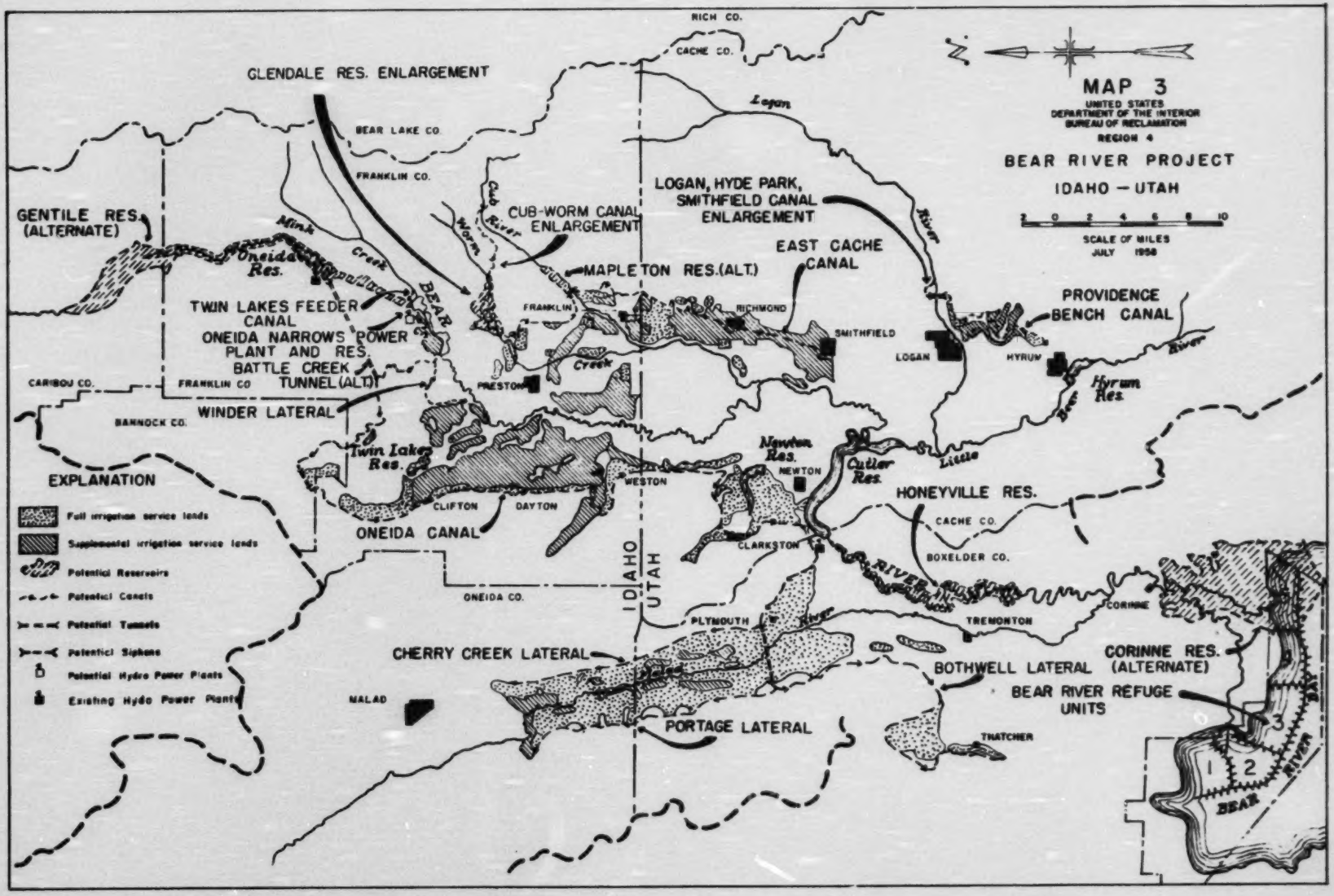
Proposed Bureau of Reclamation Project

Future reclamation development of the Bear River Basin would greatly affect streamflows and water quality. Therefore, a brief description of potential developments is considered essential to this report.

Under the project plan presently under consideration by the Bureau of Reclamation, water would be developed for irrigation, power production, municipal and industrial use, and wildlife propagation. Water would be provided for a total of 80,500 acres of land, including approximately 50,000 acres of full irrigation service land and 30,500 acres of supplemental service land. The increased water supply provided by the project would amount to 211,000 acre-feet annually. In general, the area west of Bear River would be served by development of the main stem while the area east of the river would be served by development of Cub River and Mink Creek and by exchanges involving water of Logan River. The proposed developments are indicated on Map 3.

Principal regulation of river accretions below Bear Lake and above Cache Valley would be provided at the potential Oneida Narrows Reservoir. The reservoir would be formed by a dam 300 feet high that would be constructed on Bear River at a point approximately 12 miles northeast of Preston, Idaho. The reservoir would have a total capacity of approximately 272,000 acre-feet, including about 130,000 acre-feet of active capacity. Part of the water from the reservoir would be released to Bear River through a powerplant at the toe of the dam and the remainder would be released to the potential Oneida Canal heading at the west side of the reservoir. Some of the releases to Bear River would be used under existing downstream rights. Releases surplus to such rights would be reregulated at the potential Honeyville Reservoir, approximately 50 miles downstream from the potential Oneida Narrows Reservoir, and used for the Bear River Migratory Bird Refuge and for potential municipal and industrial expansion in the lower Bear River area. Water would be released to the potential Oneida Canal at a point about 255 feet above streambed and conveyed to lands west of Bear River in Cache Valley, to Malad Valley, and Bothwell Pocket.

Project water for lands east of Bear River and for municipal use would be developed primarily from Cub River. Water exchanges would be made with the flows of Mink Creek, Logan River, and other local streams. Cub River flows would be regulated at the 28,000 acre-foot capacity Glendale Reservoir enlargement that would be formed on the river, 3½ miles northeast of Preston, Idaho, by a dam approximately 130 feet high. The East Cache Canal would head at the reservoir and extend south along the east side of Cache Valley to Summit Creek, near Smithfield, Utah, distributing water to lands enroute. In the vicinity of Smithfield, the East Cache Canal would serve some lands that now receive water from Logan River. Logan River water would thus be released for irrigation of lands south of Logan River and for municipal purposes in Logan and River Heights. In exchange, Logan would divert additional water into its municipal system from springs that are tributary to Logan River. The remaining released flows of the river would be distributed through new facilities to the Providence Bench area for irrigation use and, by exchange agreements, some additional water would be made available for municipal use in River Heights.


MAP 3
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
REGION 4
BEAR RIVER PROJECT
IDAHO — UTAH
SCALE OF MILES
JULY 1958
GLENDALE RES. ENLARGEMENT
GENTILE RES. (ALTERNATE)
Oneida Res.
TWIN LAKES FEEDER CANAL
ONEIDA NARROWS POWER PLANT AND RES.
BATTLE CREEK TUNNEL (ALT.)
WINDER LATERAL
Twin Lakes Res.
ONEIDA CANAL
CUB-WORM CANAL ENLARGEMENT
MAPLETON RES. (ALT.)
LOGAN, HYDE PARK, SMITHFIELD CANAL ENLARGEMENT
EAST CACHE CANAL
PROVIDENCE BENCH CANAL
Hyrum Res.
HONEYVILLE RES.
Newton Res.
Cutler Res.
CHERRY CREEK LATERAL
PORTAGE LATERAL
BOTHWELL LATERAL
BEAR RIVER REFUGE UNITS
CORINNE RES. (ALTERNATE)
IDAHO
UTAH
RICH CO.
CACHE CO.
BEAR LAKE CO.
FRANKLIN CO.
CARIBOU CO.
BANNOCK CO.
ONEIDA CO.
BOXELDER CO.
Logan
Mink Creek
Cub River
Worm Creek
BEAR RIVER
Little Bear River
FRANKLIN
PRESTON
RICHMOND
SMITHFIELD
LOGAN
HYRUM
WESTON
CLIFTON
DAYTON
NEWTON
CLARKSTON
PLYMOUTH
TREMONTON
CORINNE
MALAD
THATCHER
EXPLANATION
Full irrigation service lands
Supplemental irrigation service lands
Potential Reservoirs
Potential Canals
Potential Tunnels
Potential Siphons
Potential Hydro Power Plants
Existing Hydro Power Plants

Effects of the Bear River Project on Water Quality in the Bear River

Irrigation of 483,000 acres of basin lands accounts for the depletion of the Bear River by an estimated 652,000 acre-feet annually. Based on mean annual flow of 1,221,000 acre-feet at Corinne during 1949-57, this amounts to a mean annual reduction in flow at Corinne of about 35 percent. Estimates indicate that this reduction in flow has been responsible for increasing the concentrations of total dissolved solids at Corinne by about 53 percent.

If the Bear River Basin were ultimately developed according to the plan presently contemplated by the Bureau of Reclamation, the flow of Bear River would be further depleted by an estimated 130,000 acre-feet annually at Corinne. The total dissolved solids at Corinne would be increased by about 12 percent.

Based upon information obtained during this study and upon water quality data obtained from the Bureau of Reclamation, the concentrations of total dissolved solids and the annual salt load carried in the Bear River were determined for these separate locations. These locations are -

(1) Bear River at Oneida, Idaho - nearest gaging station on the Bear River above project area. Water quality at this location will not be affected by the proposed project.

(2) Bear River at Cutler Dam - intermediate point within the project area.

(3) Bear River at Corinne - lowest gaging station on the Bear River. (Gaging station discontinued in 1957.) Full effect of project development on water quality will be apparent at this location.

Table 12 shows the concentration of total dissolved solids, annual salt load carried in the Bear River, and stream flow under both present and proposed stream regimen. The concentration of total dissolved solids and the annual salt load under proposed stream regimen were determined using a weighted annual mean concentration and assuming a water and soil salt balance of 1:1. Maximum, minimum, and seasonal variations are not reflected in Table 12.

Table 12
Concentration of total dissolved solids and annual salt load

Location	Total dissolved solids: Weighted annual mean (PPM)	Total dissolved solids: Tons per acre-foot	Annual: Flow (acre-feet)	Annual: Salt load (tons)
	Present		Present	
Bear River at Oneida, Idaho	440	0.60	564,000	338,000
Bear River at Cutler Dam, Utah	450	0.61	1,171,000	715,000
Bear River at Corinne, Utah	1,340	1.82	1,221,000	2,220,000
	With project		With project	
Bear River at Oneida, Idaho	440	0.60	564,000	338,000
Bear River at Cutler Dam, Utah	521	0.71	899,000	639,000
Bear River at Corinne, Utah	1,500	2.04	1,091,000	2,220,000

Summary

This study is concerned with the chemical and bacteriological quality of the Lower Bear River as well as with the discharge of domestic and industrial wastes and return flows that have an effect upon water quality. Water samples were collected from 12 stations established on the Lower Bear River and its major tributaries between the Utah-Idah border and the outlet into Bear River Bay. The sampling period extended from July 1958 to September 1959 but samples were not taken from each station for the entire period.

The discharge of untreated and partially treated industrial and domestic wastes to the Bear River and its tributaries is largely responsible for the high bacterial content of the river water at most of the sampling stations that were utilized during the study. The discharge of untreated sugar plant wastes to the Cub and Malad Rivers is apparently responsible for extensive pollution of these streams and the Bear River below the plant outlets during October and November when these plants are operating. Water released from the Cutler Reservoir for power generation during the winter months would be stored in the proposed Honeyville Reservoir. Operation of the Honeyville Reservoir would provide water of a higher quality than is presently experienced during the summer months. When adequate treatment plant facilities have been provided for domestic and industrial wastes, the Bear River and its tributaries between the Utah-Idaho border and the proposed Honeyville Dam should provide water that would serve as a satisfactory source of supply for domestic purposes and some industrial uses. The section of the Bear River between Cutler Dam and Corinne, under present stream regimen, is unsuitable for domestic purposes and most industrial uses. The high salt content of the Malad and Bear Rivers in the vicinity of Corinne makes the water in this area unsuitable for domestic purposes and most industrial uses.

Recommendations

In view of the foregoing it is recommended that:

1. The following sections of the Lower Bear River be currently considered as satisfactory sources of water supply for domestic purposes and some industrial uses:
   (a) Bear River between the Idaho-Utah border and station 7, located above the mouth of the Cub River.
   (b) Cub River above its confluence with Worm Creek.
   (c) Logan River above Logan, Utah.
   (d) Little Bear River above the mouth of Logan River.

2. The following streams in the areas referred to, be considered as unsatisfactory sources of water supply for domestic and industrial purposes until adequate treatment plant facilities have been provided for the major sources of domestic and industrial waste pollution:

(a) Bear River between the mouth of the Cub River and Cutler Dam.
(b) Cub River between the mouth and its confluence with Worm Creek.
(c) Worm Creek between Preston, Idaho, and its confluence with the Cub River.
(d) Logan River below Logan, Utah.
(e) Little Bear River between the Logan River and Cutler Reservoir.

4. The Bear River below Cutler Dam and the lower reaches of the Malad River, under present stream regimen, be considered unsatisfactory as a source of supply for domestic and industrial purposes.

5. The water pollution control agencies in Idaho and Utah be encouraged to initiate a water pollution control program to abate pollution of the Bear River and its tributaries in the study area.

APPENDIX A

Memorandum Covering

Proposed Study of Water Quality of the

Lower Bear River

Appendix A
Exhibit I

COPY

Memorandum July 15, 1958

To: Regional Director

From: C. T. Wright, Sanitary Engineer Director

Subject: Proposed Study of Water Quality of the Lower Bear River

A conference was held at the Utah State Department of Health on July 11, 1958, to plan the proposed water quality study of the Lower Bear River. In addition to the writer the following attended the meeting:

Mr. Phil Pack, Chief, Engineering Division, Logan Development Office, Logan, Utah
Mr. L. M. Thatcher, Chief, Bureau of Sanitation, State Department of Health, Salt Lake City, Utah
Mr. Cal Sudweeks, Sanitary Engineer, State Department of Health

It was agreed that the proposed study would be conducted under the following conditions:

1. Duration of study.--About one year from the initial date of sampling, July 29, 1958.

2. Samples to be collected.--Samples to be collected for complete chemical analysis and bacteriological examination during each sampling period. Water temperature to be recorded during sampling.

3. Frequency of sampling.--At about monthly intervals.

4. Laboratory results.--Results of chemical analysis will include the constituents listed on the back of State form entitled "Water Sample for Chemical Analysis." Bacteriological results will include coliform organisms listed as M.P.N. per 100 ml.

5. Sampling schedule:

(a) July 29, 1958
(b) August 26, 1958
(c) September 23, 1958
(d) October 28, 1958
(e) November 25, 1958
(f) December 23, 1958
(g) January 27, 1959

(h) February 24, 1959
(i) March 24, 1959
(j) April 28, 1959
(k) May 26, 1959
(l) June 23, 1959

6. Location of sampling stations and their designations:

(1) Bear River near Corinne, at highway bridge on U. S. 30-S.
(2) Malad River at highway bridge on U. S. 30-S.
(3) Bear River near Collinston at highway bridge about 100 feet above gauging station.
(4) Little Bear River below mouth of Logan River at Valley View Highway Bridge, State Highway 69.
(5) Bear River about 2 miles above Cutler Reservoir at Amalga-Benson Bridge.
(6) Cub River above mouth at Trenton-Richmond Bridge on State Highway 170.
(7) Bear River above mouth of Cub River at Trenton-Richmond Bridge on State Highway 170.

Note: Use numbers listed with above descriptions in identifying samples.

7. Location of existing and proposed gauging stations:

(1) Bear River near Corinne. Gauging station formerly operated by U.S.G.S.--to be re-established.
(2) Malad River at highway bridge on U. S. 30-S--to be established.
(3) Bear River near Collinston, existing U.S.G.S. gauging station.
(4) Little Bear River. Flows to be estimated from information collected by G. A. Ward, consulting engineer.
(5) Utah Power and Light cableway near Amalga about 4 miles above sampling station--to be established.
(6) Cub River above mouth at Trenton-Richmond Bridge on State Highway 170--to be established.
(7) Bear River above mouth of Cub River at Trenton-Richmond Bridge on State Highway 170.

8. Services to be provided by the Utah State Department of Health:

(a) Sample bottles and labels to be furnished by the Bureau of Laboratories.

(b) All chemical analyses and bacteriological examinations to be made by the Bureau of Laboratories.

(c) Furnish copies of the laboratory results to Bureau of of Reclamation, Region 4, Salt Lake City, and the Logan Development Office, Logan, Utah.

9. Services to be provided by the Bureau of Reclamation, Logan Field Office:

(a) Collect samples and deliver them to Bureau of Laboratories, 45 South Fort Douglas Blvd., Salt Lake City, prior to 5 p.m. the same day of collection.

(b) Collect and assemble stream flow records at the above gauging stations.

(c) Furnish copy of stream flow records to Utah State Department of Health and Bureau of Reclamation, Region 4.

(d) Assemble laboratory results and prepare report covering study.

10. Proposed changes.--Changes in conducting the study to be handled by an exchange of correspondence between the Bureau of Sanitary Engineering, Utah State Department of Health, Salt Lake City, Utah, and the Logan Development Office, Logan, Utah, with copies of correspondence to be forwarded to Bureau of Reclamation, Region 4, Salt Lake City, Utah.

Appendix A
Exhibit II

COPY

May 25, 1959

To: L. M. Thatcher, Chief, Bureau of Sanitation

From: C. T. Wright, Sanitary Engineer Director, Public Health Service

Subject: Continuation of Lower Bear River Water Quality Study Beyond July 1, 1959

It is my understanding that the Lower Bear River water quality study will be conducted under the following conditions between July 1 and September 30, 1959.

1. Duration of revised sampling schedule

   July 1 through September 1959.

2. Frequency of sampling schedule

   Semi-monthly intervals.

3. Proposed sampling schedule

   July 14 and 28.
   August 11 and 25.
   September 8 and 22.

4. Samples to be collected

   (a) All sampling stations.--Samples to be collected for complete chemical analysis and bacteriological examination during each sampling period. Water temperature to be recorded during sampling.

   (b) First sampling station below Cutler Dam and all sampling stations above Cutler Reservoir, with the exception of the Little Bear River. In addition to the samples referred to under item 4a, samples from these stations should be collected for dissolved oxygen and biochemical oxygen demand. The partial analysis for dissolved oxygen and pH determination will be made in the field at these stations.

5. Location of sampling stations and their designation

   (1) Bear River near Corinne, at highway bridge on U. S. 30-S.

(2) Malad River at highway bridge on U. S. 30-S.

(8) Bear River at highway bridge west of Honeyville.
Note: This supplemental station was established during March 1959.

(3) State No. 25. Bear River near Collinston at highway bridge about 100 feet above gauging station.

(4) Little Bear River below mouth of Logan River at Valley View Highway Bridge, State Highway 69.

(5) State No. 23. Bear River about 2 miles above Cutler Reservoir, 2 miles west of Smithfield on north-south road (about 1½ miles south of Amalga).

State No. 30. Cub River above mouth about 2 miles below Trenton-Richmond Bridge on State Highway 170.
Note: Station No. 6 was located at Trenton-Richmond Bridge on State Highway 170.

State No. 13. Bear River above mouth of Cub River at highway bridge about one mile east of Cornish on State Highway No. 61.
Note: Station No. 7 was located about 2 miles east of Trenton on State Highway No. 170 about 7 stream miles below Utah Station.

State No. 16. Cub River at bridge over river on road east of Lewiston.

State No. 22. Cub River 2 miles below Amalgamated Sugar Company.

6. Location of gauging stations

(1) Bear River near Corinne. Gauging station formerly operated by U.S.G.S.

(2) Malad River at highway bridge on U. S. 30-S.

(3) State No. 25. Bear River near Collinston, existing U.S.G.S. gauging station.

(4) Little Bear River flows to be estimated by sample collector during collection of samples.

(5) State No. 23. Utah Power and Light cableway near Amalga about 4 miles above sampling station.

State No. 30. Cub River above mouth about 2 miles below Trenton-Richmond Bridge on State Highway 170.

State No. 13. Flow estimated by difference between State Station 23 and State 30.

State No. 16.

State No. 22.

7. Services to be provided by Utah State Department of Health

(a) Collect samples and read gauges at State stations numbered 22, 16, 13, 23, 30, and 25.

(b) Turn samples over to collaborating agency representative in Logan, Utah.

(c) Sample bottles and labels to be furnished by the Bureau of Laboratories.

(d) All chemical analyses and bacteriological examinations to be made by State Bureau of Laboratories.

(e) Furnish copies of laboratory results and flow records to collaborating agency.

C. T. Wright
Sanitary Engineer Director

Attachment

CTWright/ls

A P P E N D I X B

Stream Discharge, chemical constituents exceeding recommended levels, temperatures, bacteriological, dissolved oxygen, and biochemical oxygen demand by individual stations shown graphically

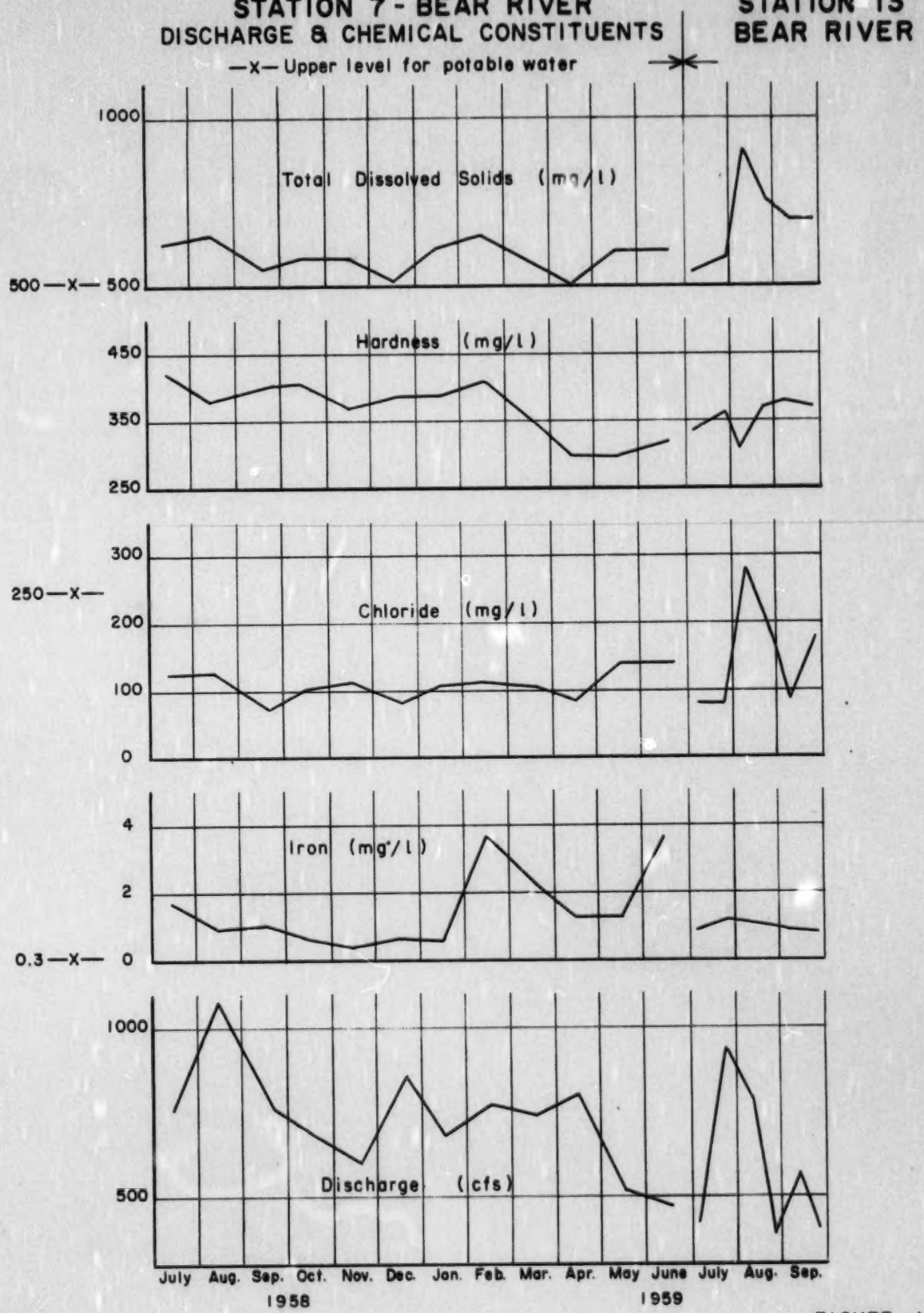

STATION 7 - BEAR RIVER
DISCHARGE & CHEMICAL CONSTITUENTS
STATION 13
BEAR RIVER
—X— Upper level for potable water
1000
Total Dissolved Solids (mg/l)
500 —X— 500
450
Hardness (mg/l)
350
250
300
250 —X—
Chloride (mg/l)
200
100
0
4
Iron (mg/l)
2
0.3 —X— 0
1000
Discharge (cfs)
500
July Aug. Sep. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sep.
1958
1959

FIGURE 1

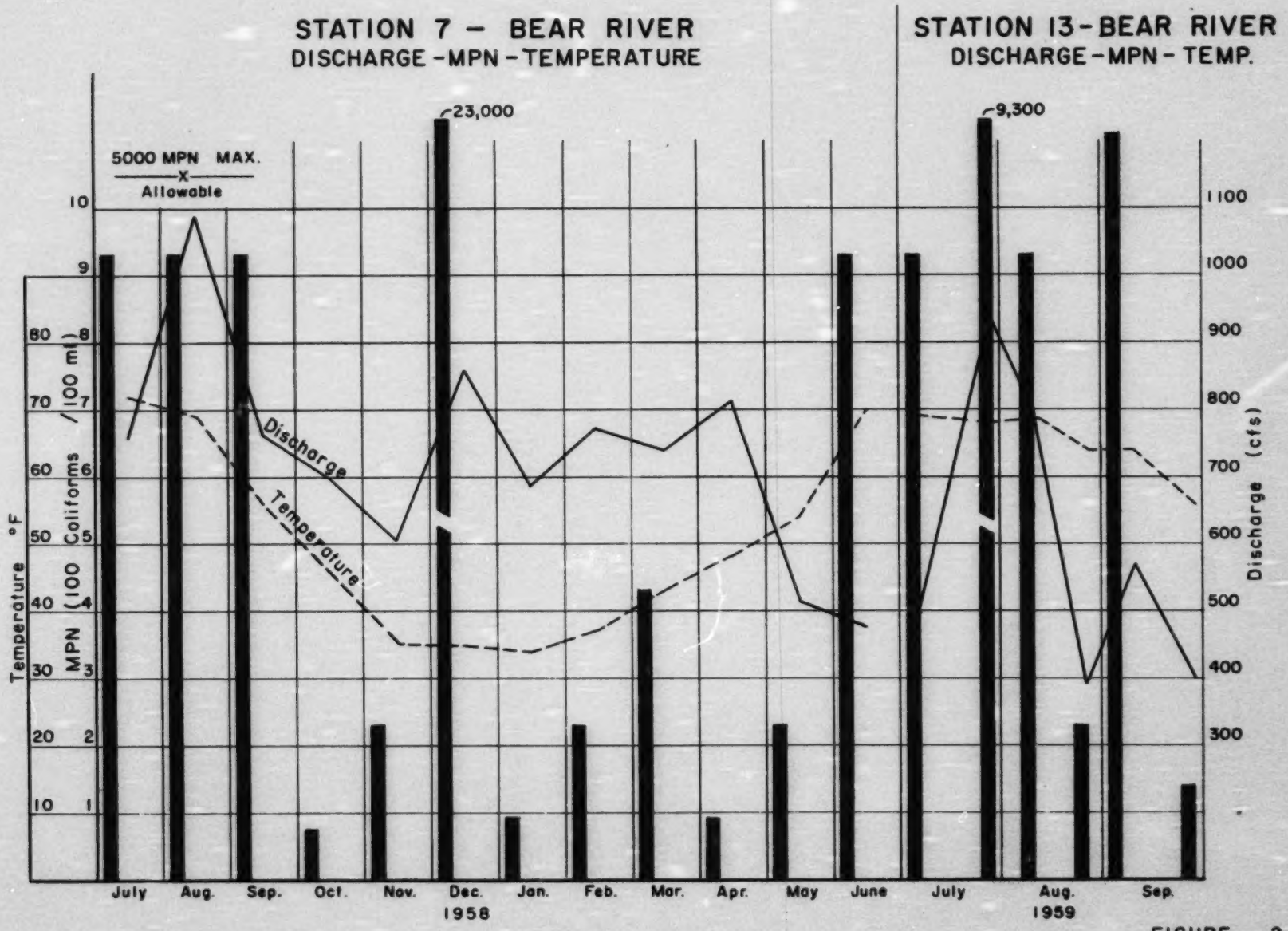

STATION 7 – BEAR RIVER
DISCHARGE - MPN - TEMPERATURE
STATION 13 - BEAR RIVER
DISCHARGE - MPN - TEMP.
23,000
9,300
5000 MPN MAX.
X
Allowable
Discharge
Temperature
Temperature °F
MPN (100 Coliforms / 100 ml)
Discharge (cfs)
July
Aug.
Sep.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sep.
1958
1959

FIGURE 2

STATION 13 - BEAR RIVER

DISCHARGE - DISSOLVED OXYGEN - TEMPERATURE BIOCHEMICAL OXYGEN DEMAND

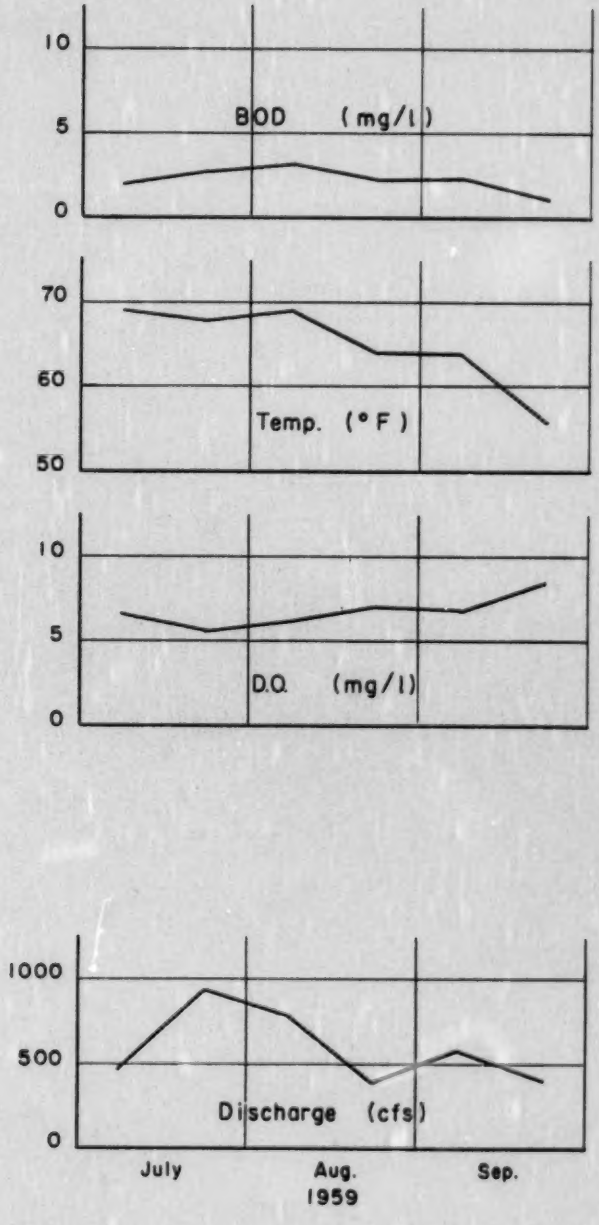


FIGURE 3

STATION 16 - CUB RIVER
DISCHARGE & CHEMICAL CONSTITUENTS

—x— Upper level for potable water

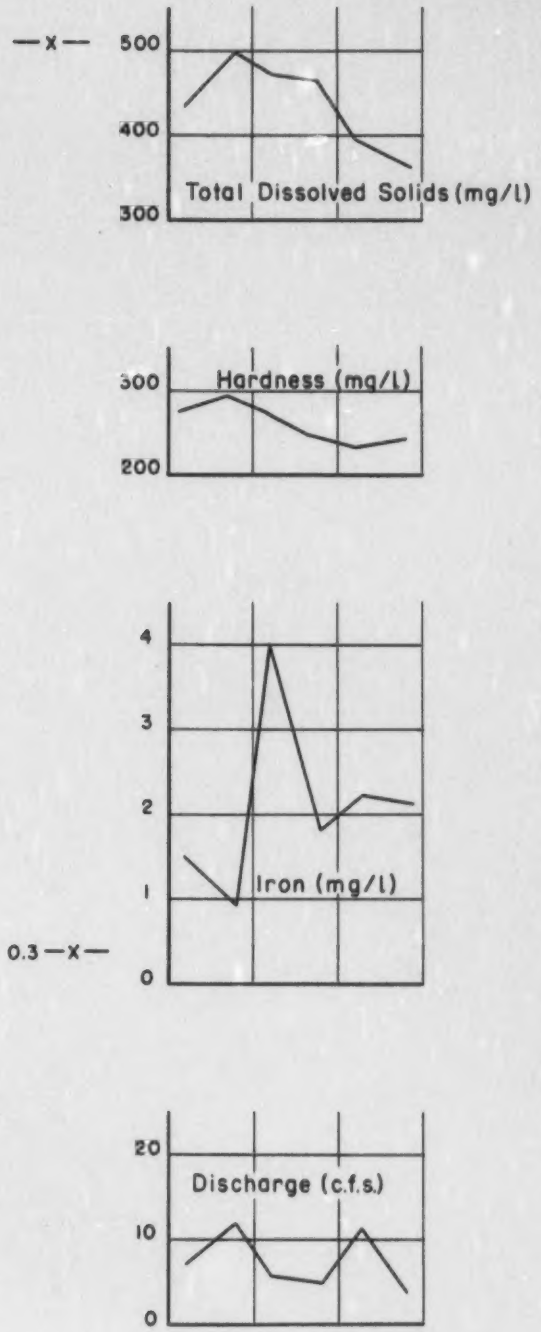


FIGURE 4

STATION 16 - CUB RIVER

DISCHARGE - MPN - TEMPERATURE

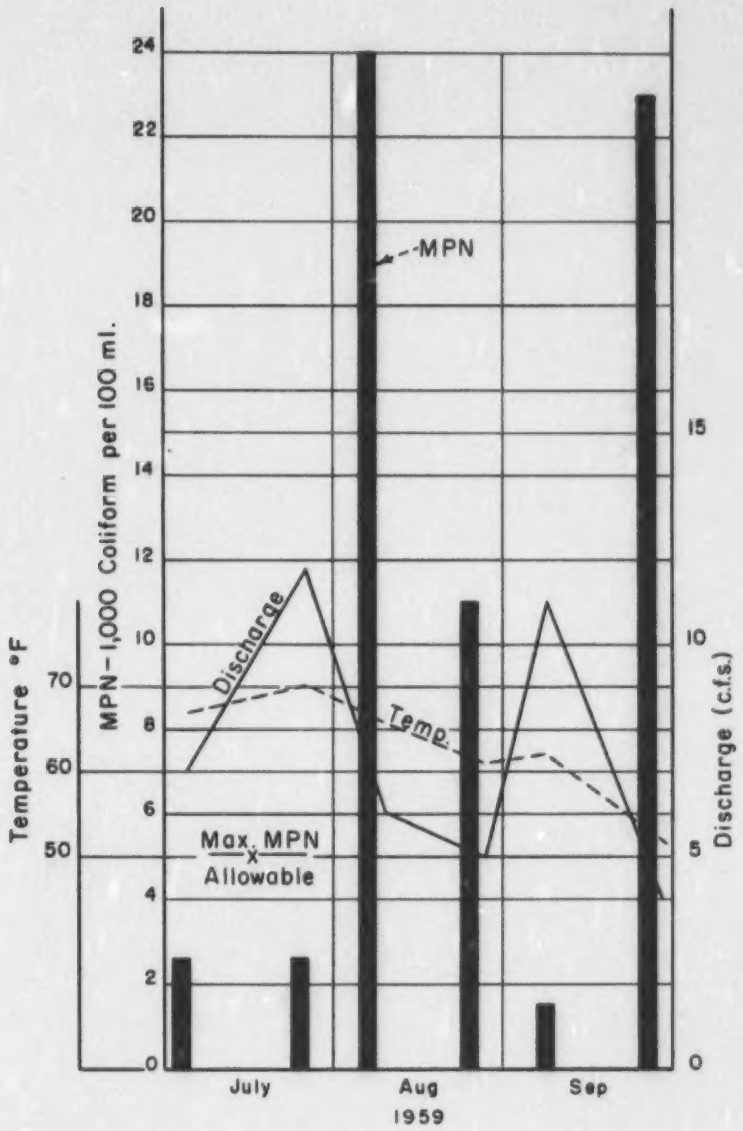


FIGURE 5

STATION 16 - CUB RIVER

DISCHARGE - DISSOLVED OXYGEN - TEMPERATURE

BIOCHEMICAL OXYGEN DEMAND

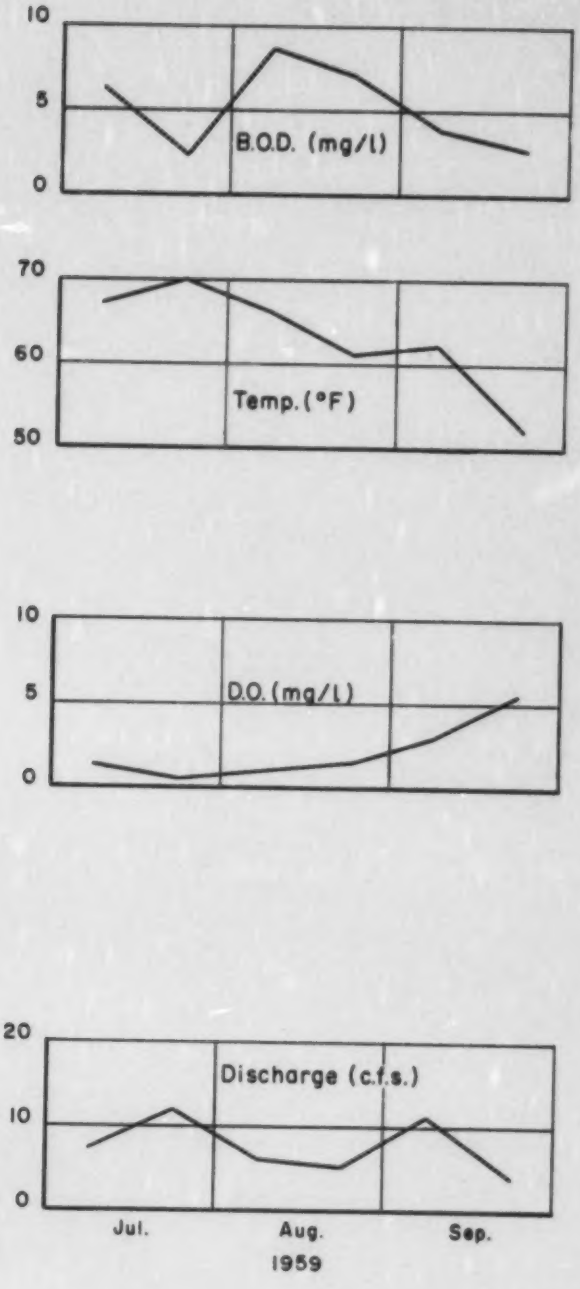


FIGURE 6

STATION 22 - CUB RIVER
DISCHARGE & CHEMICAL CONSTITUENTS

—x— Upper level for potable water

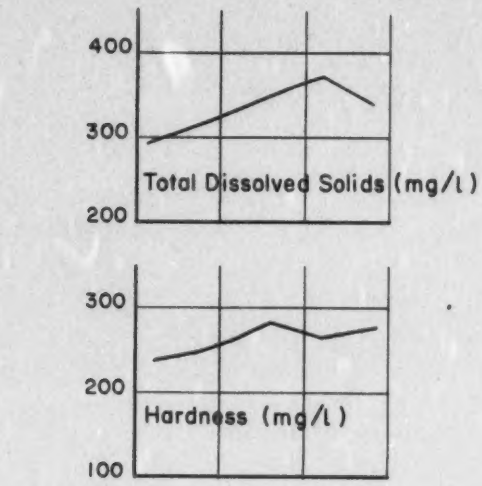


FIGURE 7

STATION 22 - CUB RIVER

DISCHARGE - MPN - TEMPERATURE

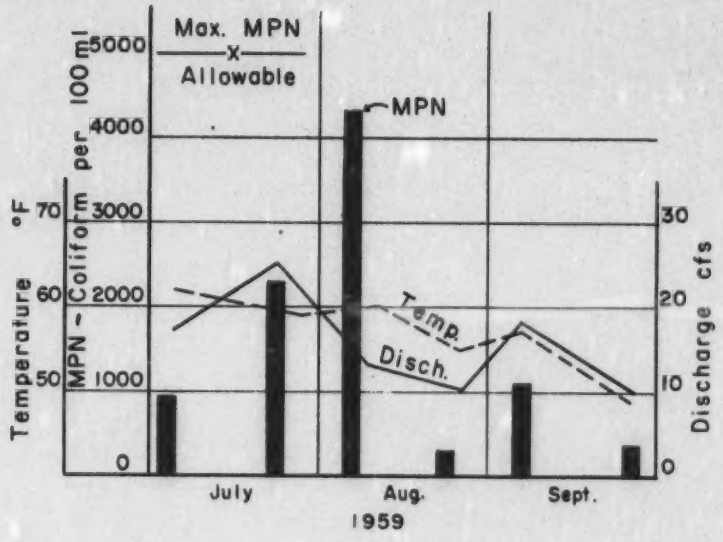


FIGURE 8

STATION 22 - CUB RIVER

DISCHARGE - DISSOLVED OXYGEN - TEMPERATURE BIOCHEMICAL OXYGEN DEMAND

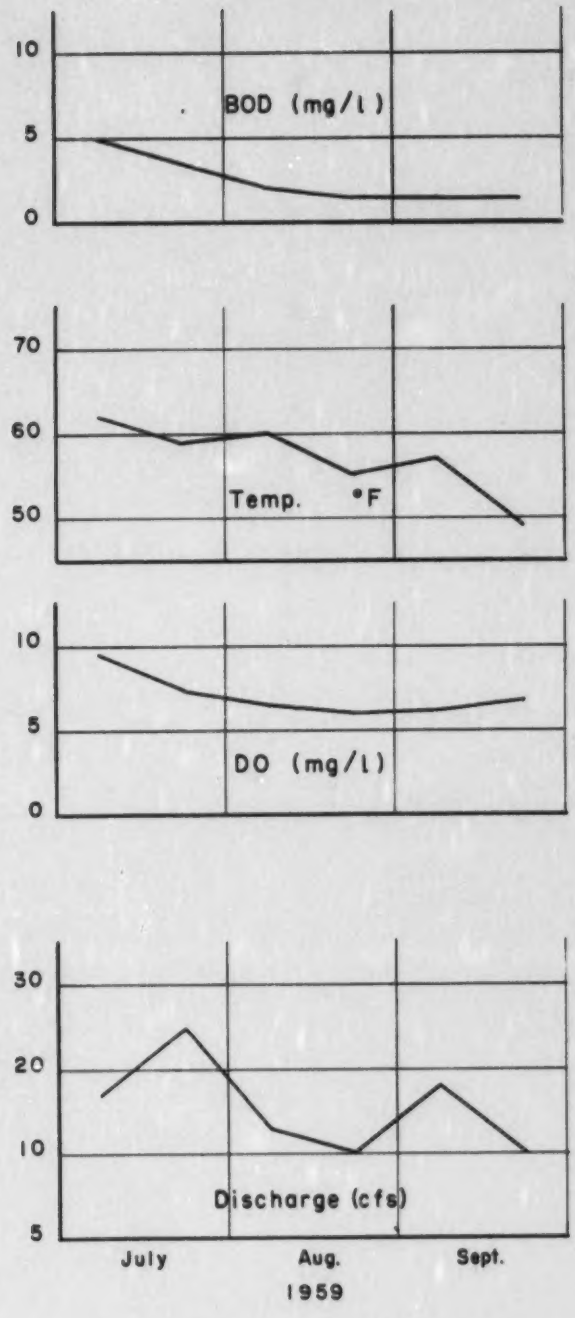


FIGURE 9

STATION 6 — CUB RIVER
DISCHARGE & CHEMICAL CONSTITUENTS

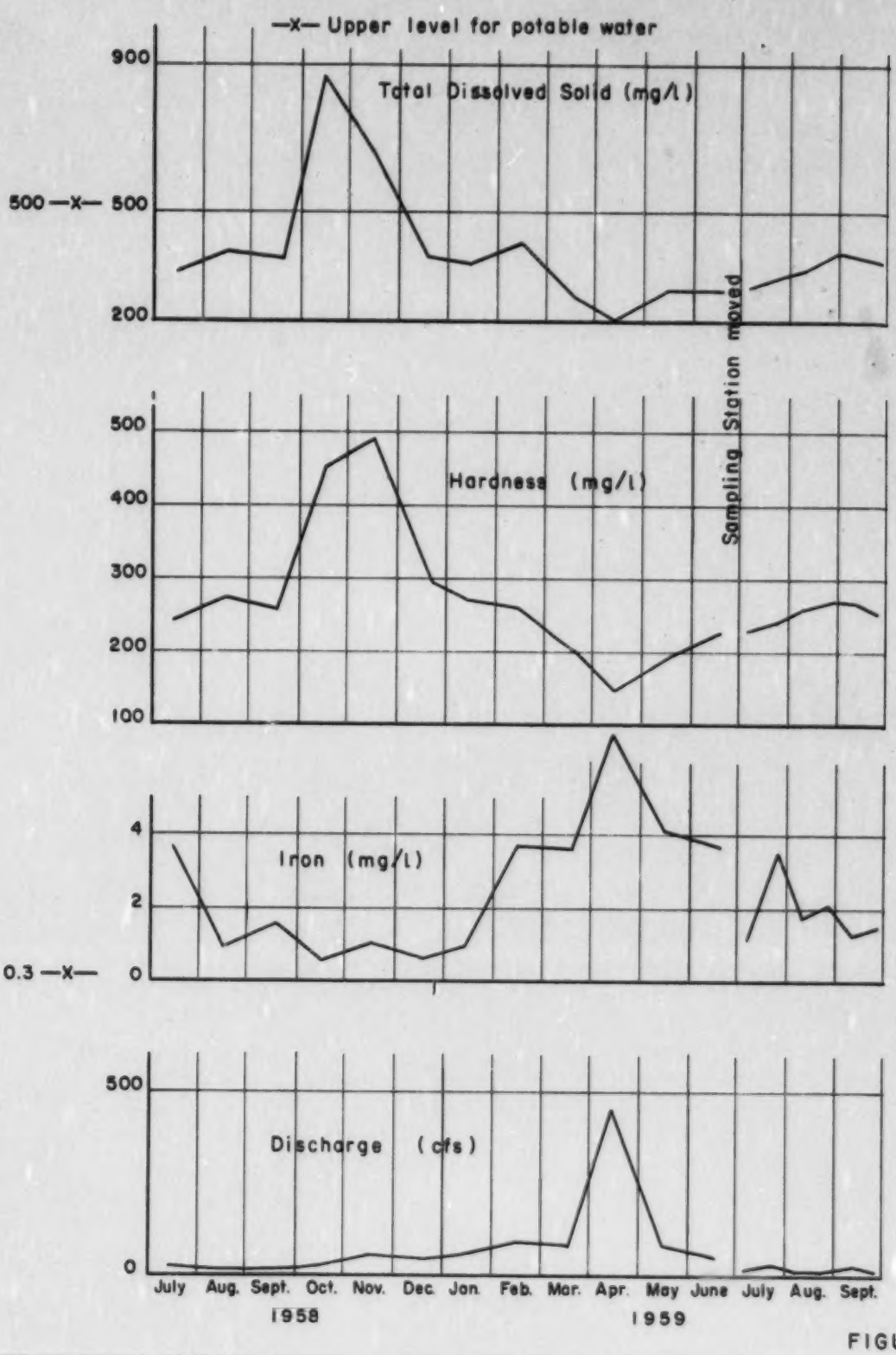


FIGURE 10

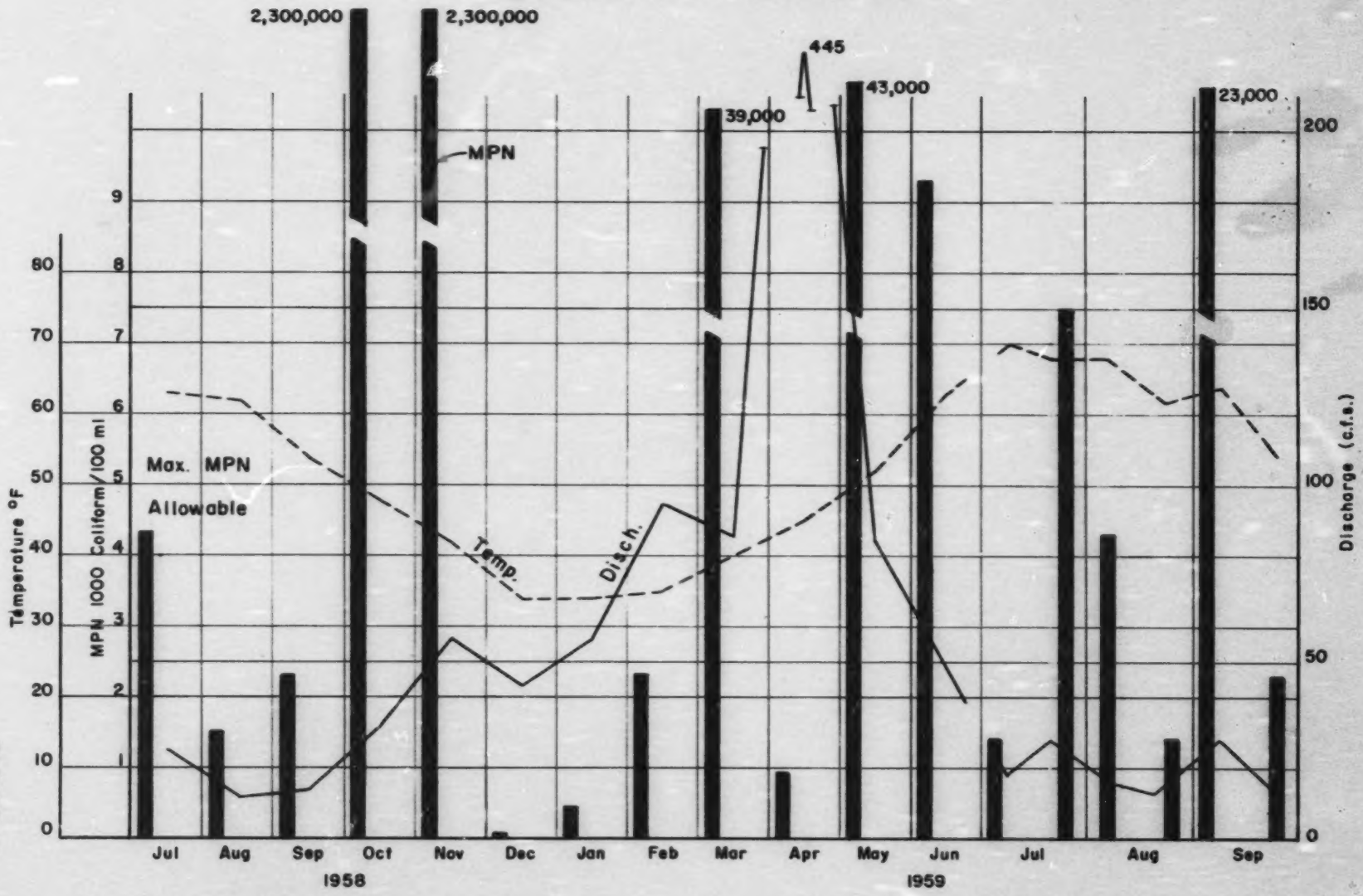

STATION 6 — CUB RIVER
DISCHARGE - MPN - TEMPERATURE
2,300,000
2,300,000
445
43,000
39,000
23,000
MPN
Max. MPN
Allowable
Temp.
Disch.
Temperature °F
MPN 1000 Coliform/100 ml
Discharge (c.f.s.)
0
10
20
30
40
50
60
70
80
1
2
3
4
5
6
7
8
9
0
50
100
150
200
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
1958
1959

FIGURE 11

STATION 6 - CUB RIVER
DISCHARGE-DISSOLVED OXYGEN-TEMPERATURE BIOCHEMICAL OXYGEN DEMAND

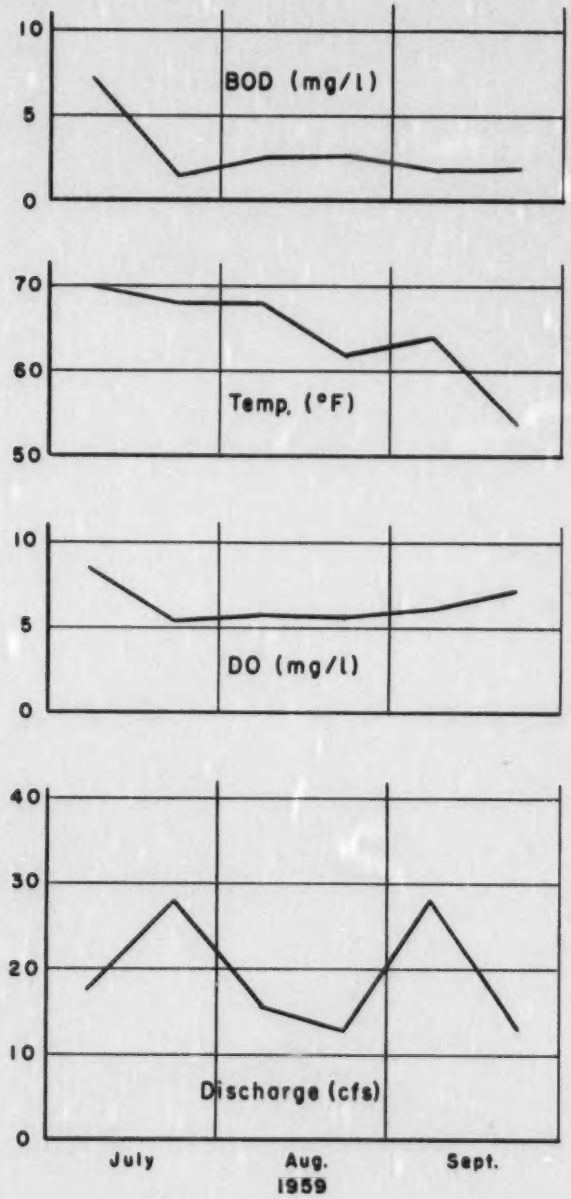


FIGURE 12

STATION 5 – BEAR RIVER
DISCHARGE & CHEMICAL CONSTITUENTS

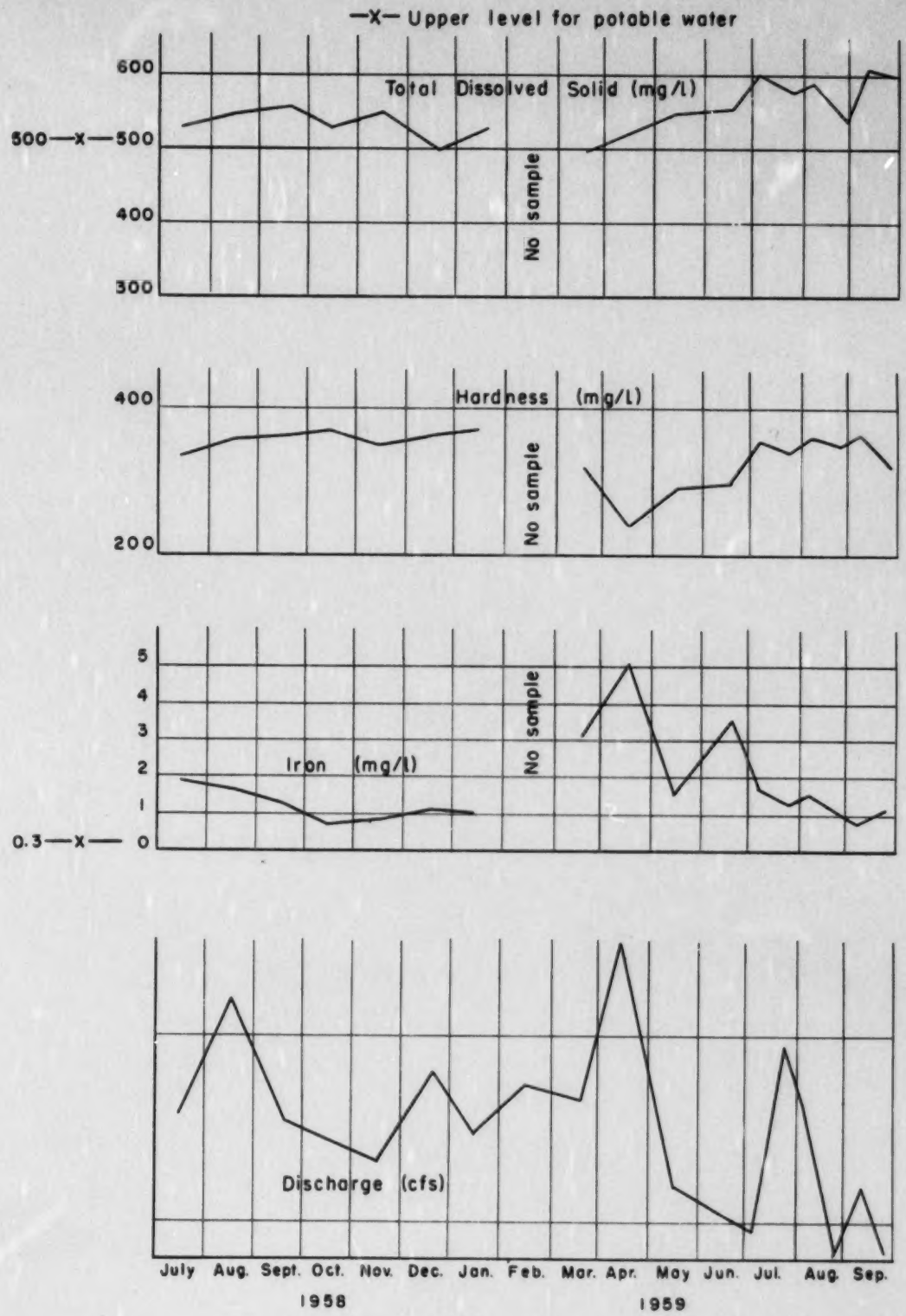


FIGURE 13

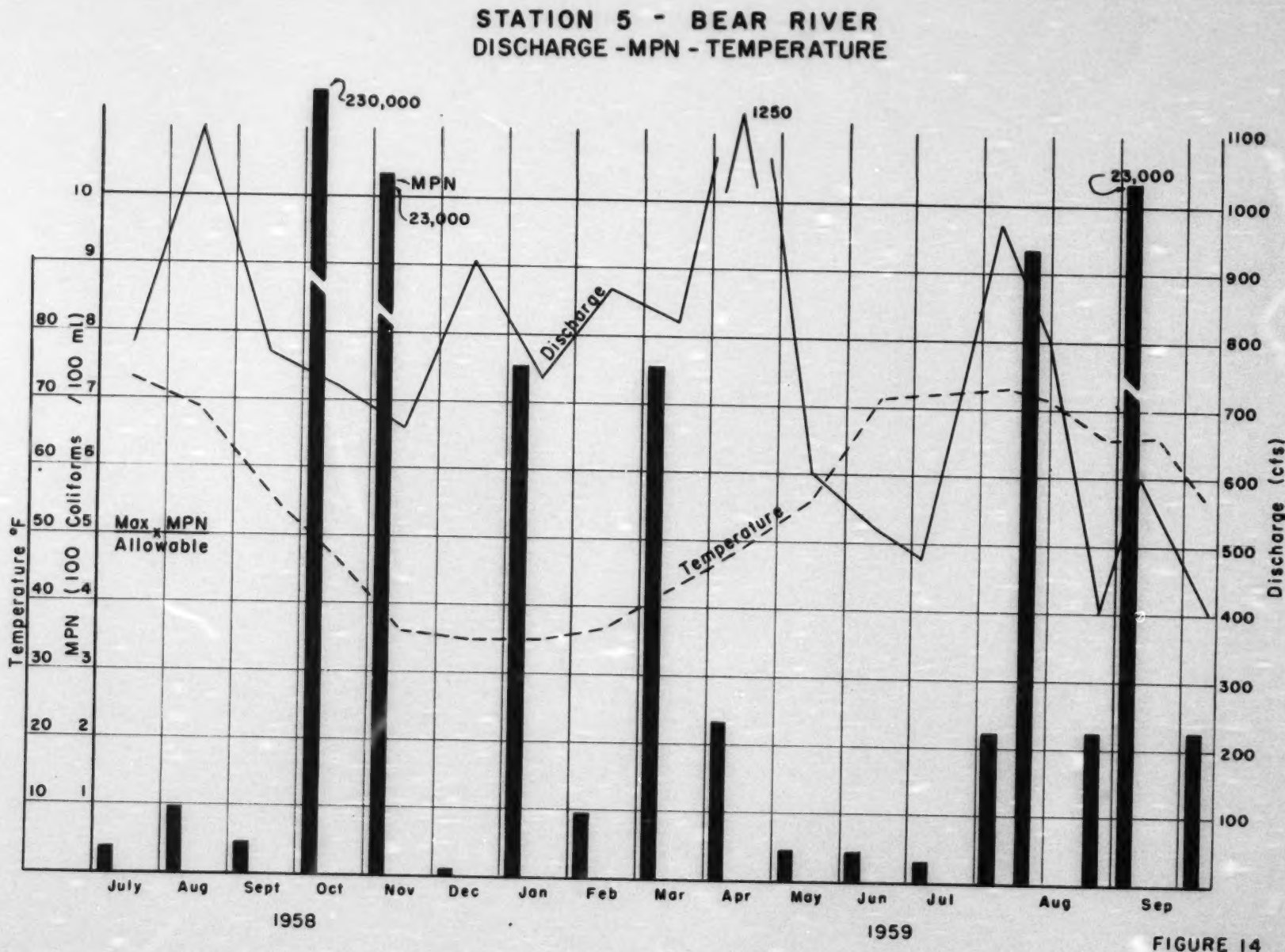

STATION 5 - BEAR RIVER
DISCHARGE - MPN - TEMPERATURE
230,000
1250
MPN
23,000
23,000
Discharge
Temperature
Max. MPN Allowable
Temperature °F
MPN (100 ml) Coliforms
Discharge (cfs)
July
Aug
Sept
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
1958
1959

FIGURE 14

STATION 5 - BEAR RIVER

DISCHARGE - DISSOLVED OXYGEN - TEMPERATURE

BIOCHEMICAL OXYGEN DEMAND

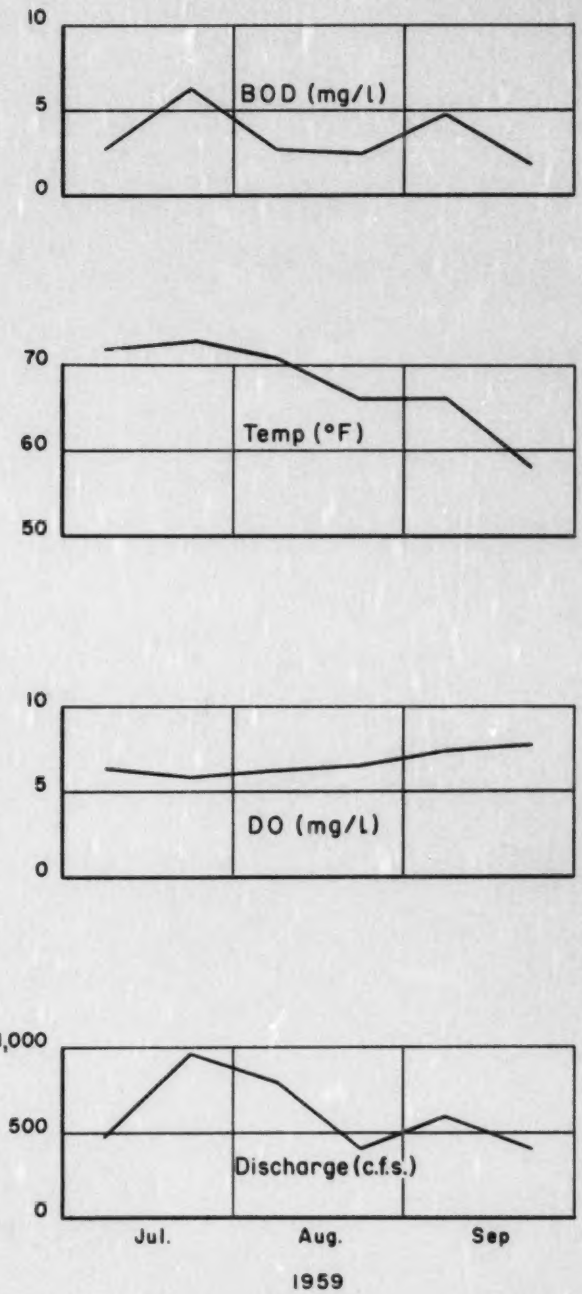


FIGURE 15

STATION 4 - LITTLE BEAR RIVER

DISCHARGE & CHEMICAL CONSTITUENTS

—x— UPPER LEVEL FOR POTABLE WATER

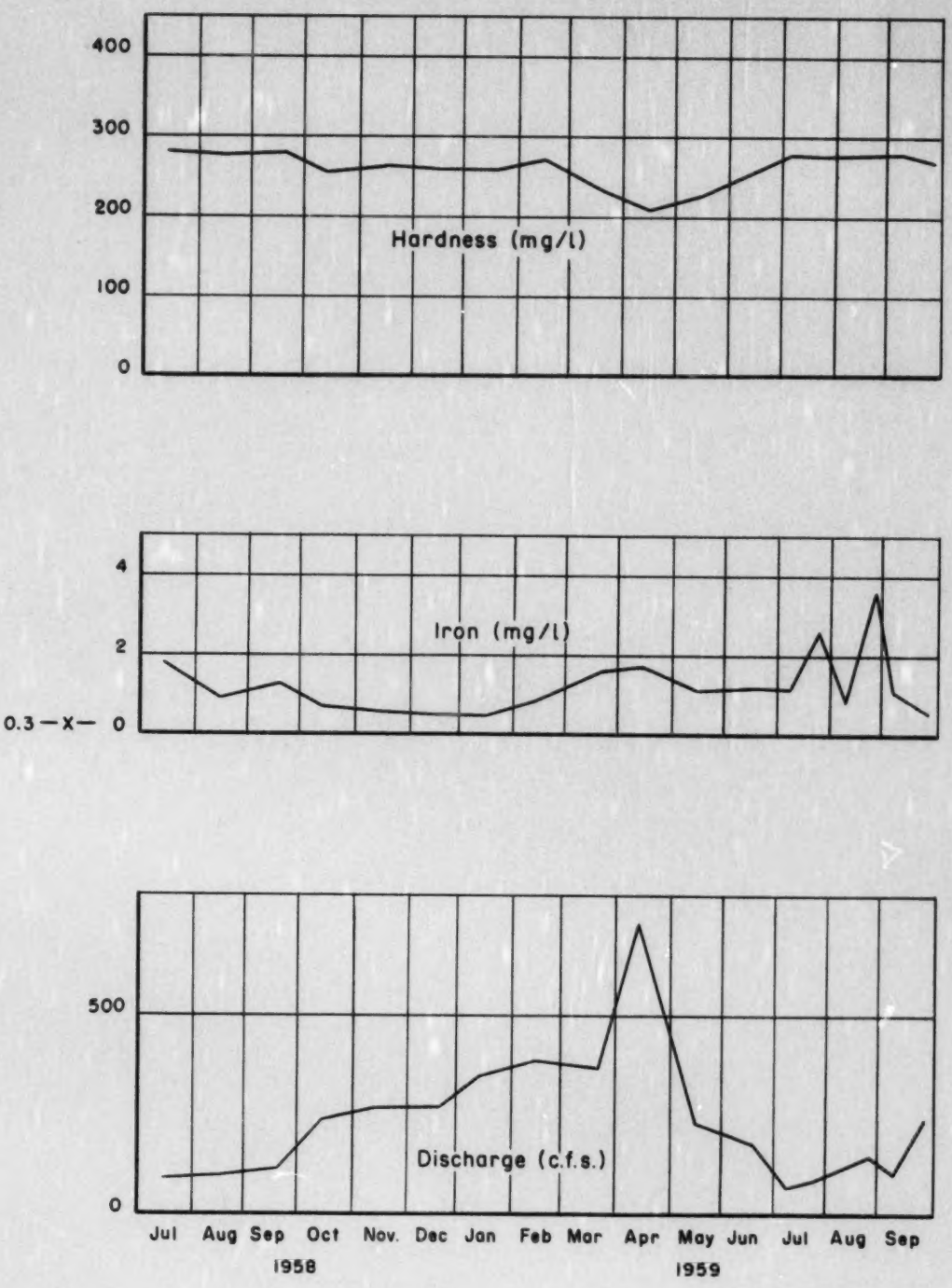


FIGURE 16

STATION 4 - LITTLE BEAR RIVER
DISCHARGE - MPN - TEMPERATURE

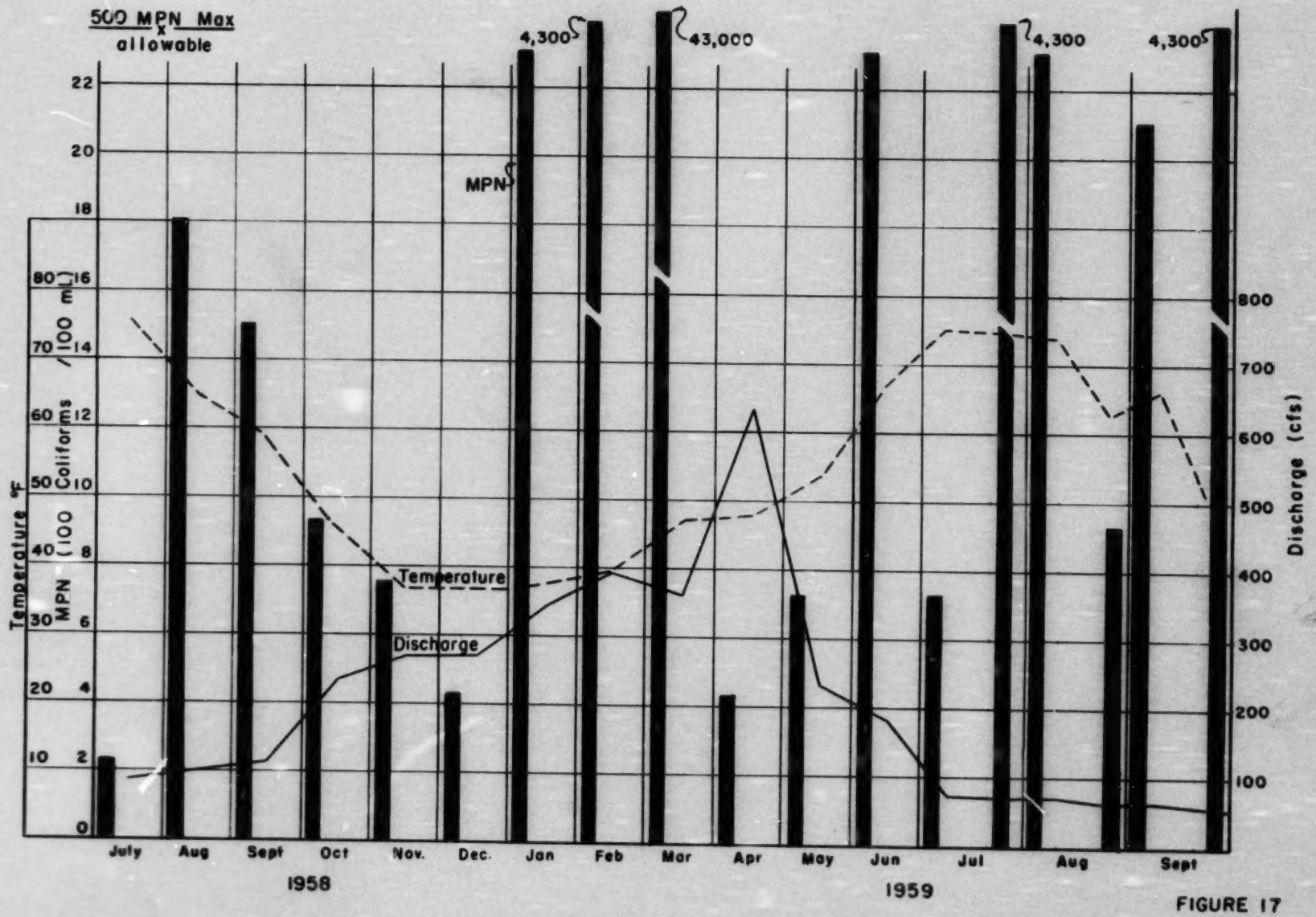


FIGURE 17

STATION 4 - LITTLE BEAR RIVER

DISCHARGE - DISSOLVED OXYGEN - TEMPERATURE

BIOCHEMICAL OXYGEN DEMAND

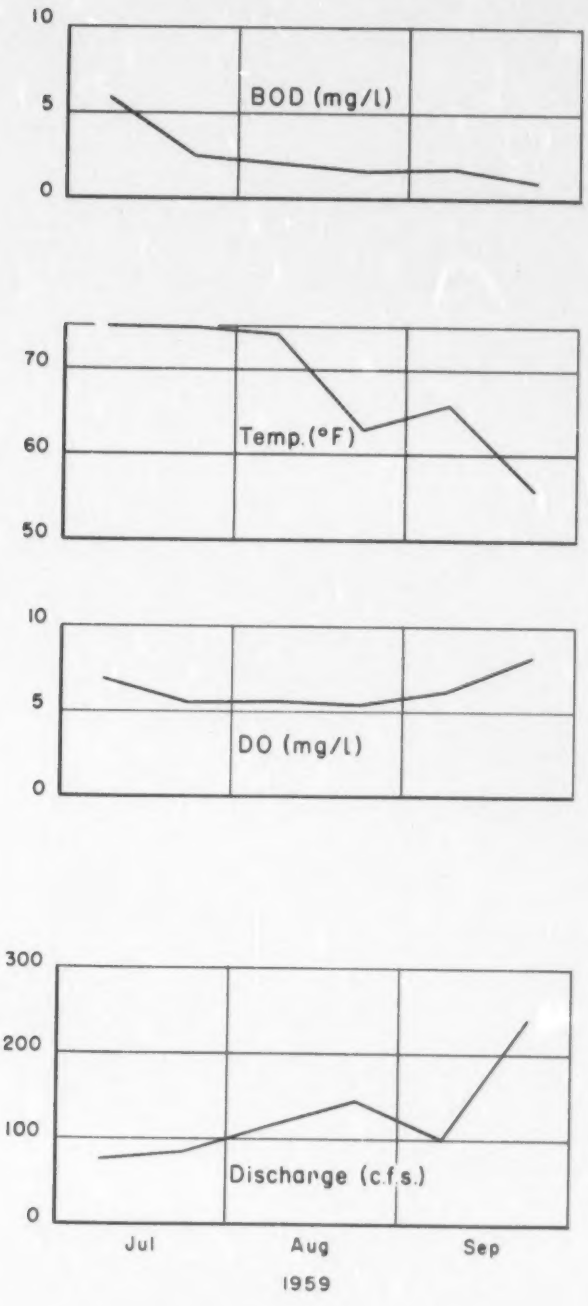
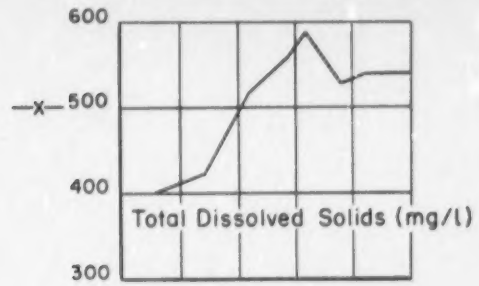


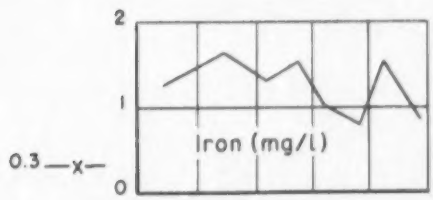
FIGURE 18

STATION 9 - HAMMOND CANAL

DISCHARGE & CHEMICAL CONSTITUENTS

—x— UPPER LIMIT FOR POTABLE WATER





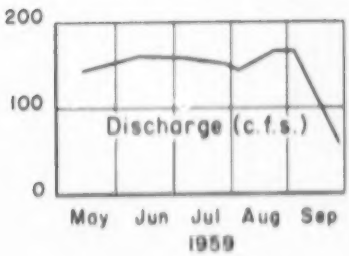


FIGURE 19

STATION 9 - HAMMOND CANAL
DISCHARGE - MPN - TEMPERATURE

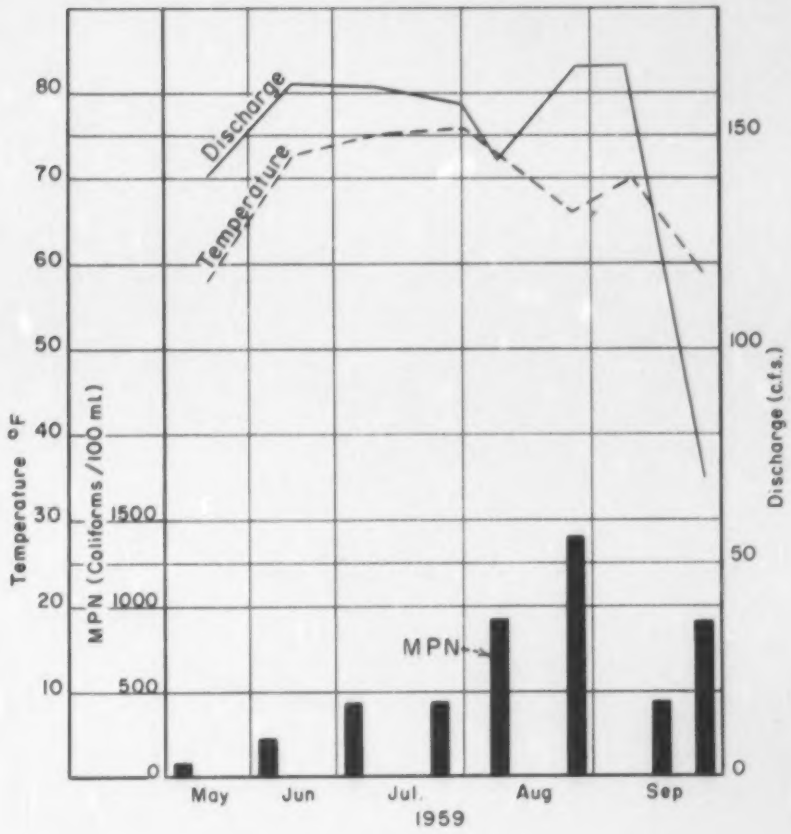


FIGURE 20

DISCHARGE & CHEMICAL CONSTITUENTS

—X— UPPER LEVEL FOR POTABLE WATER

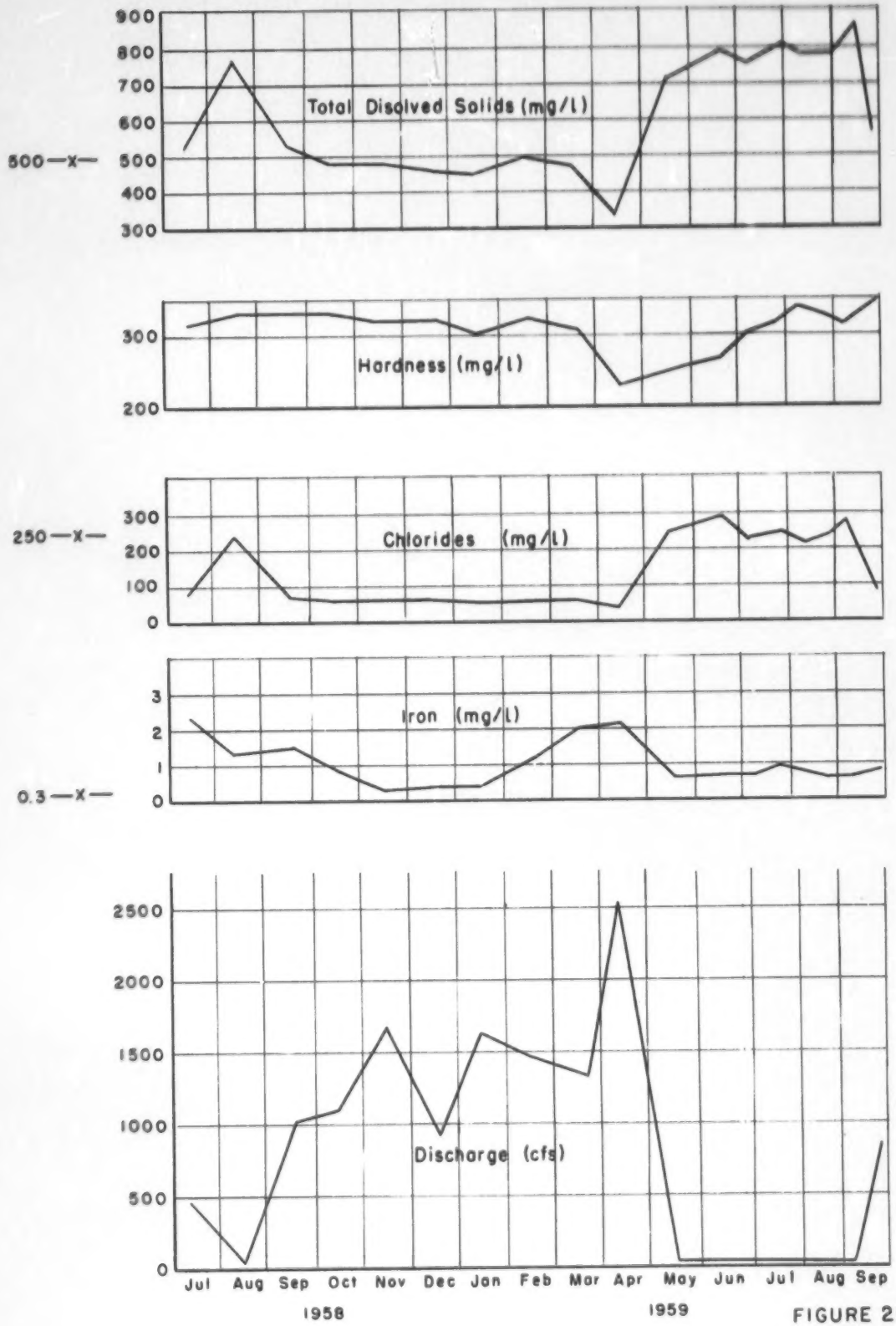


FIGURE 21

STATION 3 - BEAR RIVER

DISCHARGE - MPN - TEMPERATURE

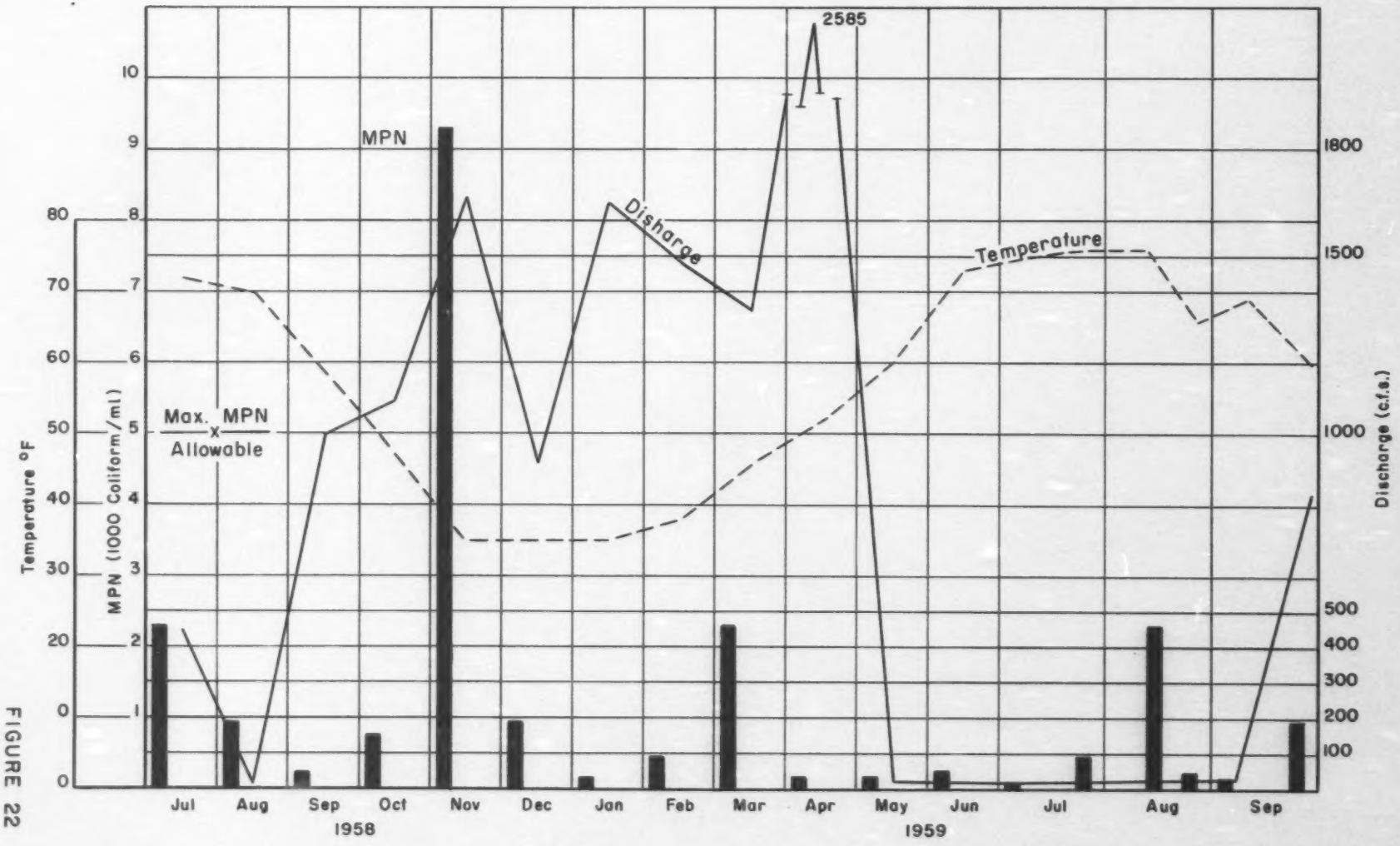


FIGURE 22

STATION 3 - BEAR RIVER

DISCHARGE - DISSOLVED OXYGEN - TEMPERATURE

BIOCHEMICAL OXYGEN DEMAND

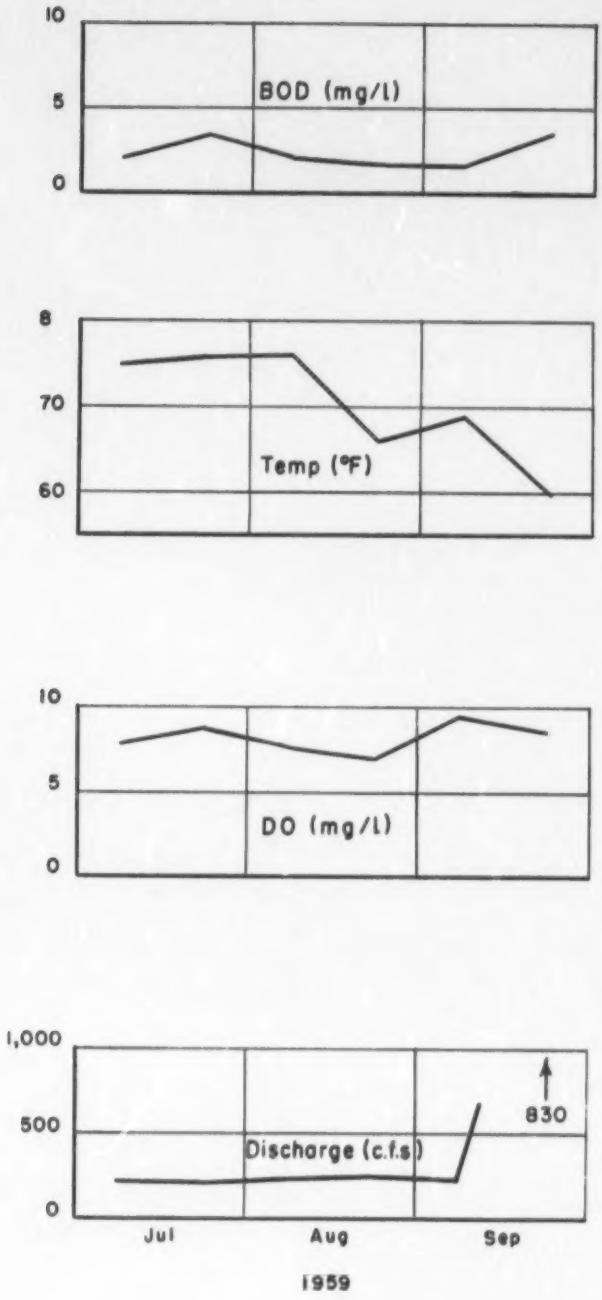


FIGURE 23

STA. 8

DISCHARGE & CHEMICAL CONSTITUENTS

—x— UPPER LEVEL FOR POTABLE WATER

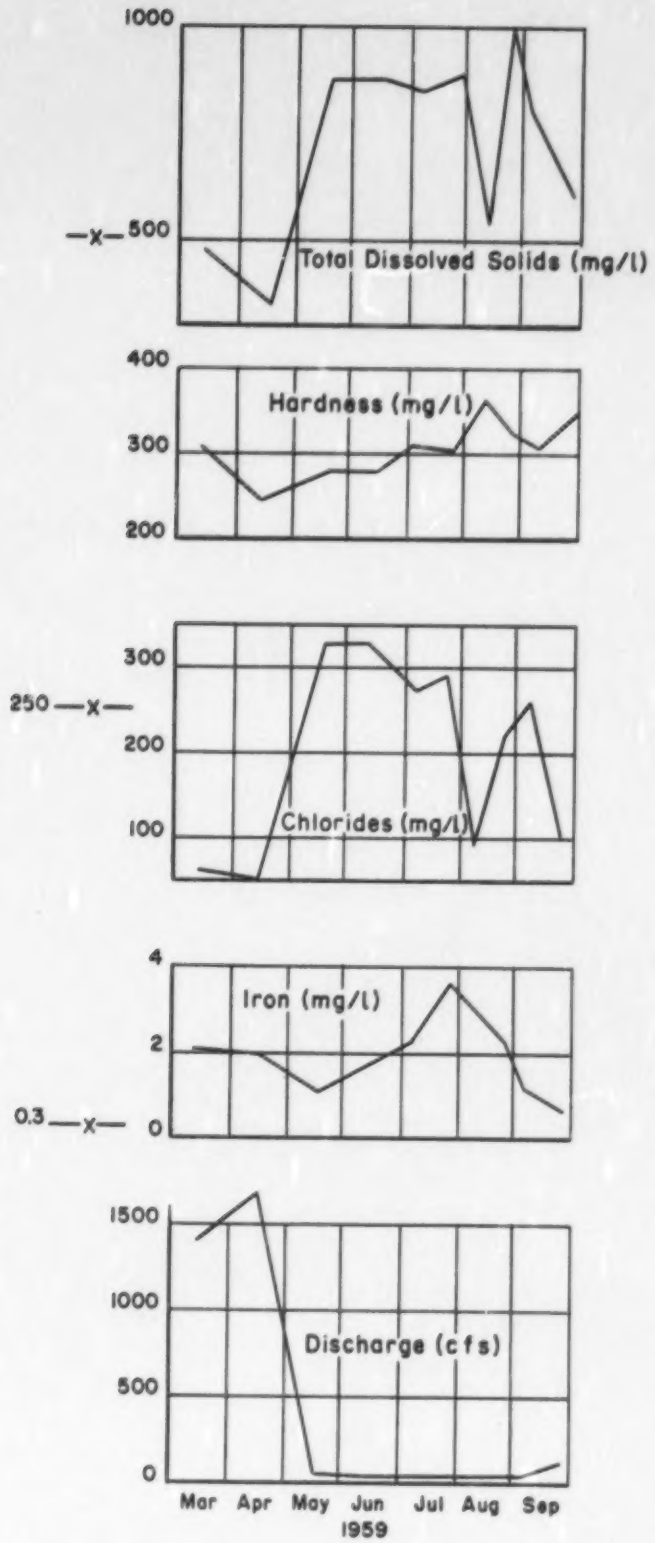


FIGURE 24

STATION 8 - BEAR RIVER

DISCHARGE - MPN - TEMPERATURE

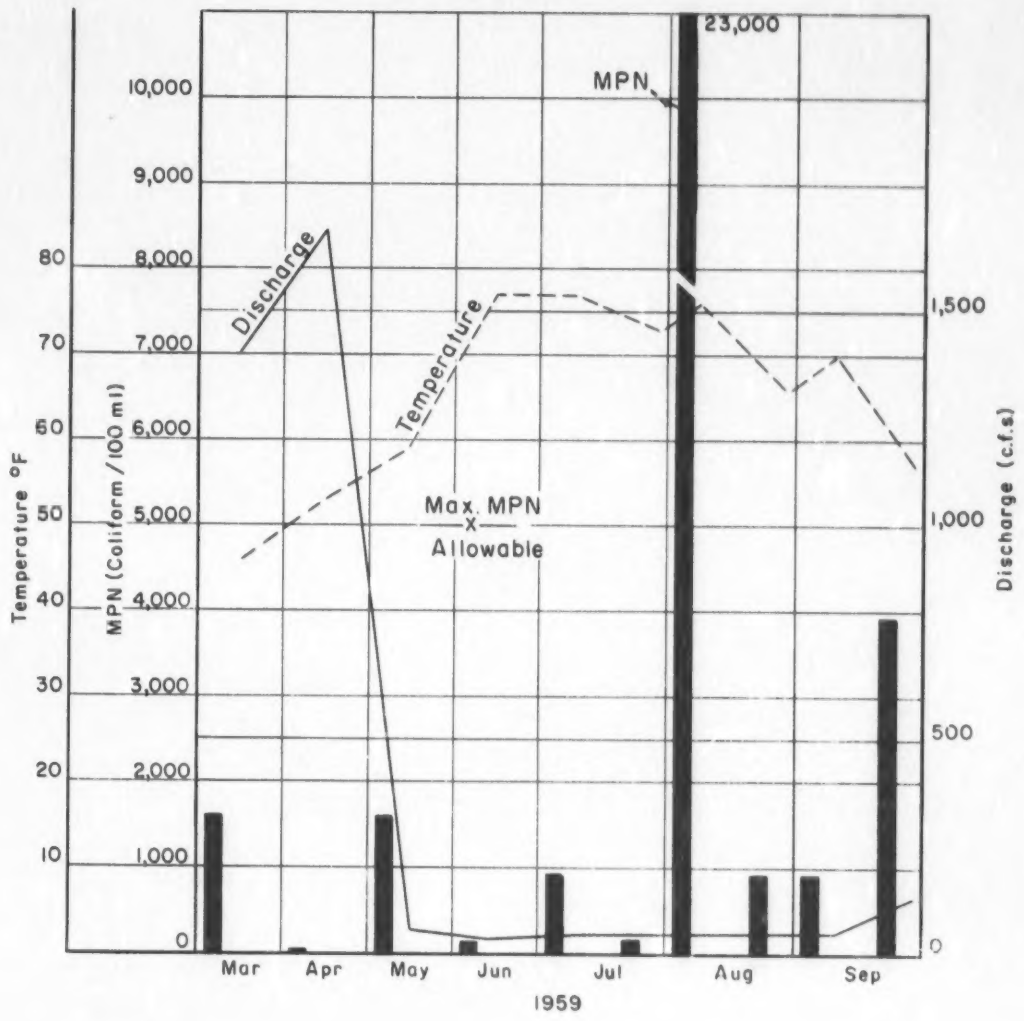


FIGURE 25

STATION 2 - MALAD RIVER

DISCHARGE & CHEMICAL CONSTITUENTS

—x— UPPER LIMIT FOR POTABLE WATER

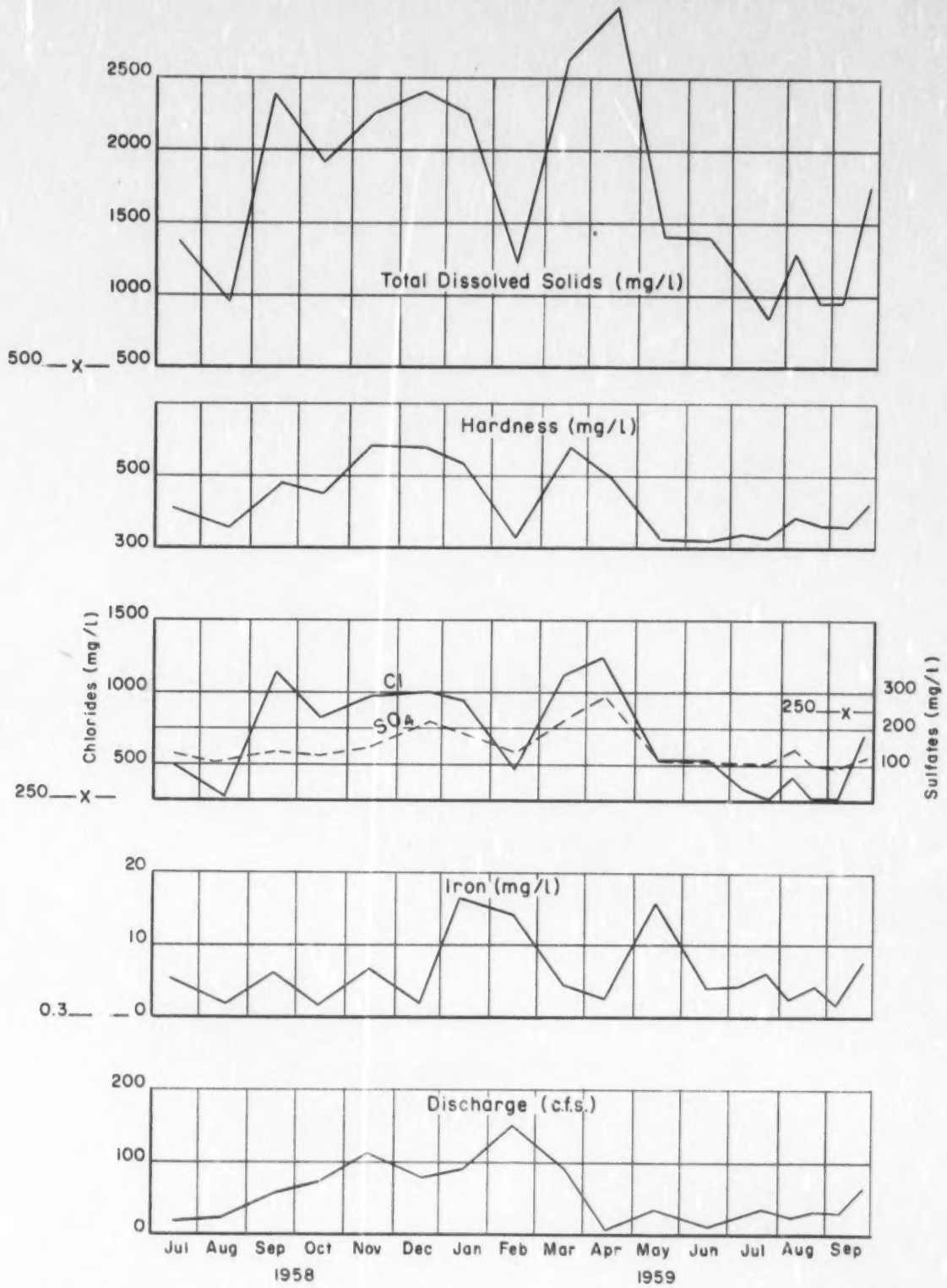


FIGURE 26

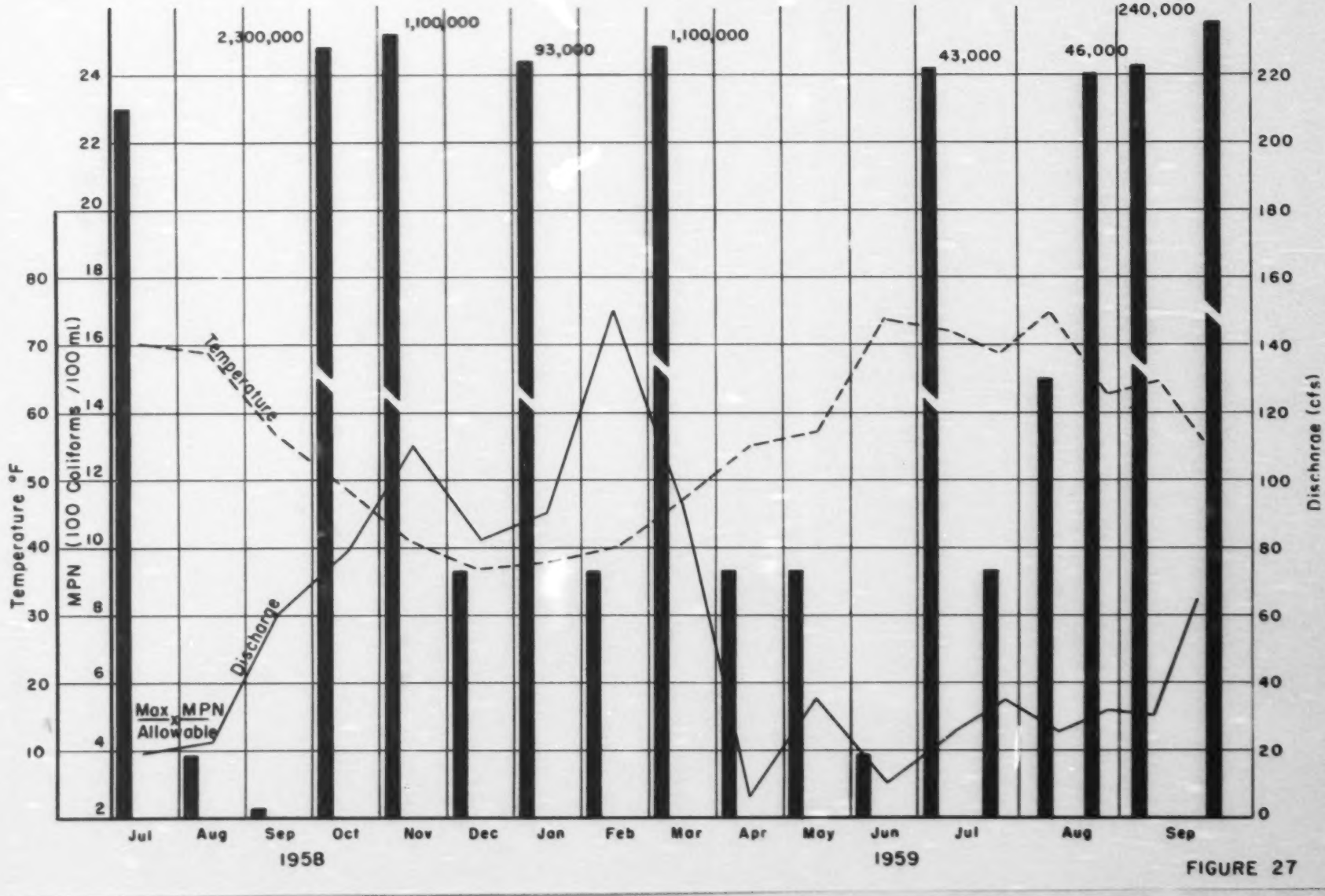

STATION 2 - MALAD RIVER
DISCHARGE - MPN - TEMPERATURE
2,300,000
1,100,000
93,000
1,100,000
43,000
46,000
240,000
Temperature
Discharge
Max MPN / Allowable
Temperature °F
MPN (100 Coliforms /100 ml)
Discharge (cfs)
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
1958
1959

FIGURE 27

STATION 1 – BEAR RIVER

DISCHARGE & CHEMICAL CONSTITUENTS

—X— UPPER LEVEL FOR POTABLE WATER

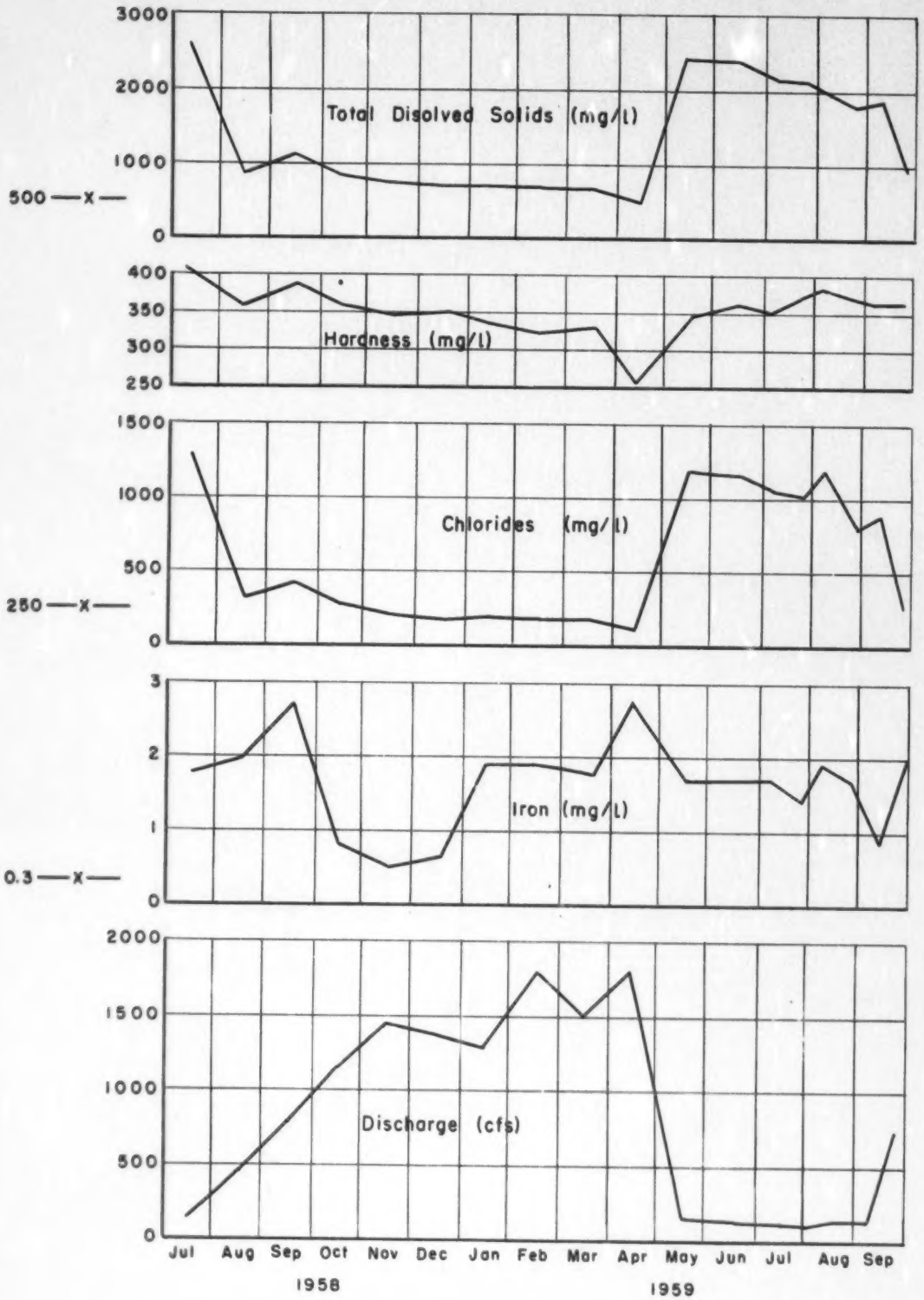


FIGURE 28

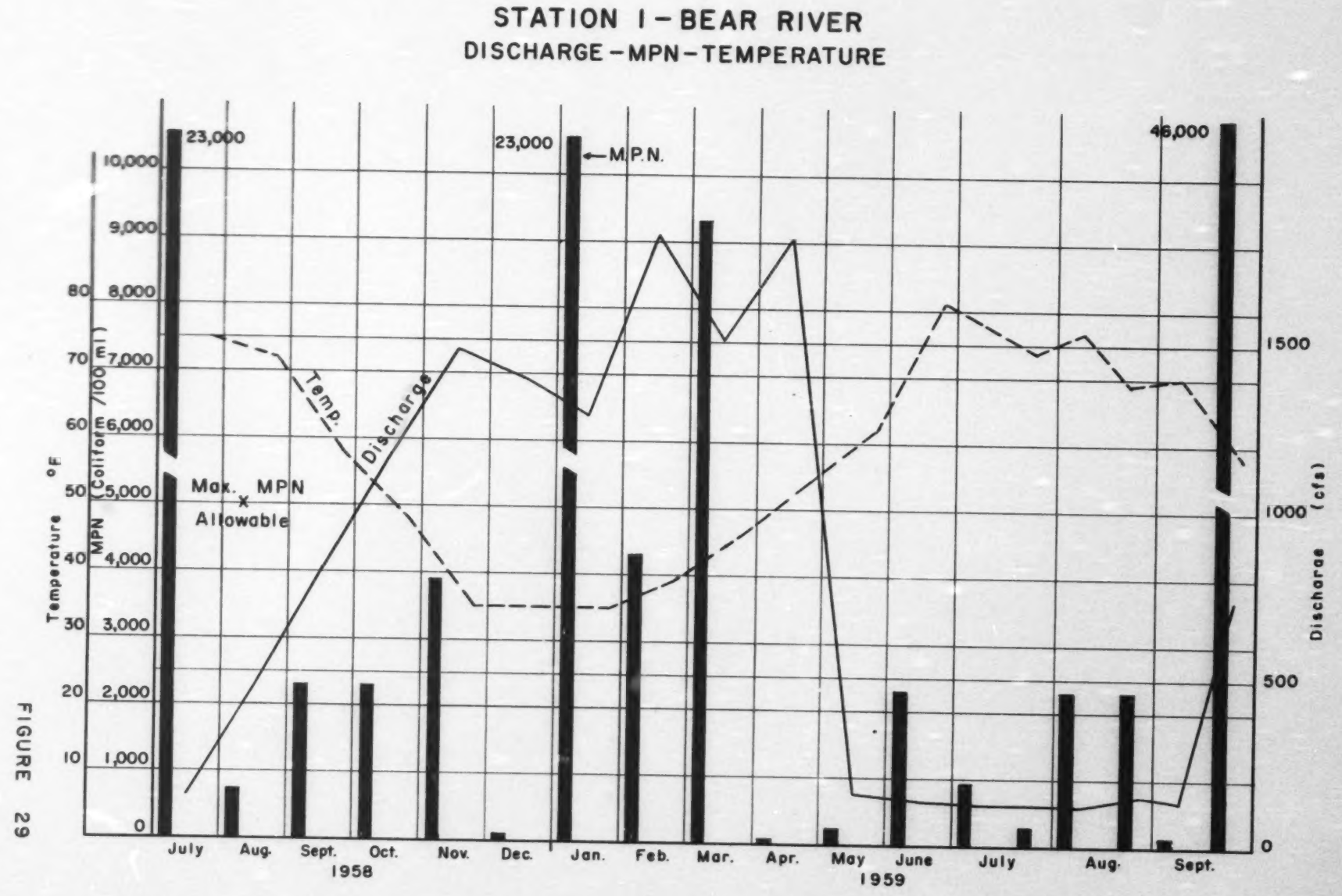
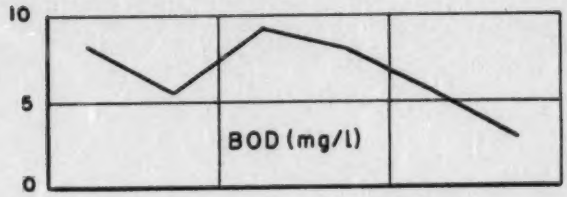

STATION 1 – BEAR RIVER
DISCHARGE – MPN – TEMPERATURE
23,000
23,000
← M.P.N.
46,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
MPN (Coliform /100 ml)
80
70
60
50
40
30
20
10
Temperature °F
Temp.
Discharge
Max. MPN
x
Allowable
1500
1000
500
0
Discharge (cfs)
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
1958
1959

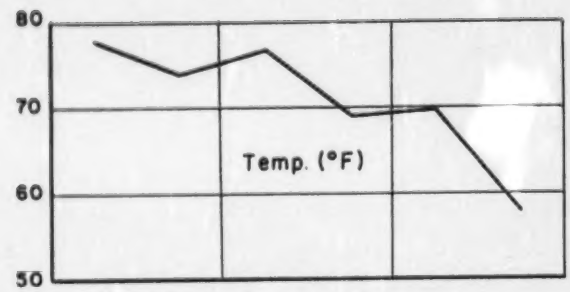
FIGURE 29

STATION 1 - BEAR RIVER

DISCHARGE - TEMPERATURE

BIOCHEMICAL OXYGEN DEMAND





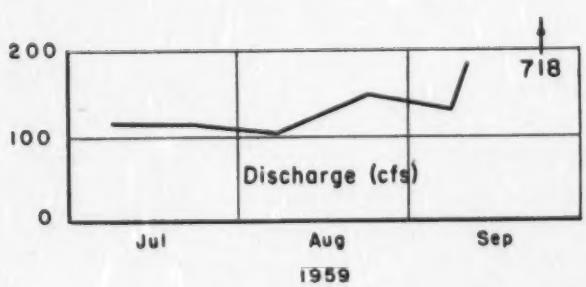


FIGURE 30

APPENDIX C

Description of sampling stations and laboratory analysis for all samples collected for the water quality study of the Lower Bear River Basin, Utah

Appendix C

Location and Description of Sampling Stations
Water Quality Studies Lower Bear River Basin

Station number	Approximate river miles above mouth	Description--sampling period-- Utah Water Pollution Control Board station number
1	B12	Bear River at Corinne at old bridge approximately 500 feet downstream from present U. S. Highway 30-S bridge. Below confluence of Bear and Malad Rivers. July 1958 - Sept. 1959. UWPCB--B26.
	B17	Malad River enters the Bear River.
2	M1	Malad River just above the confluence of the Malad and Bear Rivers at Utah State Highway 191 bridge over the Malad River, approximately 1 mile south of Bear River City. July 1958 - Sept. 1959. UWPCB--M33.
8	B23	Bear River at highway bridge west of Honeyville March - Sept. 1959.
3	B45	Bear River just below Cutler Dam at bridge about 300 feet below USGS gaging station near Collinston. July 1958 - Sept. 1959. UWPCB--B25.
9		Hammond Canal diversion from Cutler Reservoir 500 feet below Cutler Dam. May - Sept. 1959.
	B50	Little Bear River enters the Bear River.
4	LB7	Little Bear River below mouth of Logan River at Valley View Highway bridge, Utah State Highway 69, approximately 5 miles west of the Logan City limits. July 1958 - Sept. 1959. UWPCB--LB31.
5	B52	Bear River at Amalga--Benson bridge on north-south road about 3 miles west of Smithfield. July 1958 - Sept. 1959. UWPCB--B23.
	B62	Cub River enters the Bear River.
6	C2	Cub River above mouth at Trenton-Richmond Bridge on Utah State Highway 170 approximately 1.5 miles west of Richmond. July 1958 - June 1959. UWPCB--C30.1.

Station number	Approximate river miles above mouth	Description--sampling period-- Utah Water Pollution Control Board station number
	C1	Cub River west of Richmond approximately 0.7 mile above confluence of Cub and Bear Rivers at plank bridge. SE¼, Sec. 31, T. 14 N., SLB&M. July - Sept. 1959. UWPCB--C30.
22	C4	Cub River at bridge over river approximately 1,000 feet west of Valley Mill. NE¼, Sec. 21, T. 14 N., R. 1 E., SLB&M. Below Amalgamated Sugar Company. July - Sept. 1959. UWPCB--C22.
16	C6	Cub River at bridge on Utah State Highway 61 about 1.5 miles east of Lewiston. Above Amalgamated Sugar Company. July - Sept. 1959. UWPCB--C16.
7	B64	Bear River above mouth of Cub River at Trenton-Richmond bridge on Utah State Highway 170. July 1958 - June 1959. UWPCB--B32.
13	B70	Bear River at bridge on Utah State Highway 61 about 1 mile east of Cornish. July - Sept. 1959. UWPCB--B13.
	B72	Bear River, Idaho-Utah state line.

TABLE C I

Sampling Date	Discharge (cfs)	M P N Coliform per 100 ml.	Temperature ° F. *	pH	Concentration in milligrams per liter: Dissolved Oxygen * (D.O.)	Biochemical Oxygen Demand (B.O.D.)	Free Carbon Dioxide (CO_2)	Silica (SiO_2)	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Chlorides (Cl)	Nitrates (NO_3)	Sulfate (SO_4)	Fluoride (F)	Alkalinity ($CaCO_3$)	Hardness ($CaCO_3$)	Total Dissolved Solids (T.D.S.)	Boron (B)	Sampling Date
STATION NO. 1 BEAR RIVER																								
1958																								1958
7-29	137	23,000	75	3.25			3.32	6	1.79	75	54	800	50	361	3.6	1,284	1.40	103	1.10	302	409	2,568	0.20	7-29
8-26	463	750	72	8.45			2.07	15	1.98	98	28	205	13	350	5.4	315	0.26	79	0.49	296	360	910	0.17	8-26
9-23	810	2,300	58	8.45			2.14	33	2.71	88	41	272	27	361	5.6	438	0.44	77	0.42	305	391	1,169	0.23	9-23
10-28	1,156	2,300	48	8.10			4.50	12	0.86	74	43	180	22	361	2.5	270	0.26	71	0.37	300	360	854	0.14	10-28
11-25	1,468	3,900	35	7.85			7.99	12	0.50	100	24	130	10	358	1.4	203	0	55	0.12	296	347	722	0.11	11-25
12-22	1,387	93	35	8.30			2.98	7	0.68	80	37	140	1	355	3.9	190	0.54	57	0.52	298	350	705	0.08	12-22
1959																								1959
1-27	1,278	23,000	35	8.25			3.23	15	1.93	68	41	119	14	352	3.5	202	0.62	60	0.39	294	336	726	0.15	1-27
2-24	1,813	4,300	39	8.15			4.02	17	1.95	65	40	122	13	345	2.7	178	0.12	63	0.40	287	325	709	0.26	2-24
3-24	1,504	9,300	46	8.20			3.50	14	1.76	74	36	106	10	350	3.1	179	0.40	68	0.25	292	332	698	0.15	3-24
4-28	1,806	43	54	8.25			2.56	13	2.78	50	33	69	7	279	2.7	113	0.26	37	0.22	233	260	488	0.05	4-28
5-26	156	230	62	8.35			2.22	9	1.70	61	48	745	46	330	4.1	1,188	0.04	83	0.53	277	349	2,423	0.04	5-26
6-23	126	2,300	81	8.25			3.04	12	1.72	78	41	710	44	330	3.2	1,175	0.61	81	0.40	276	365	2,423	0.33	6-23
7-14	118	930	78	8.30*		8.3	2.78	7	1.70	61	49	679	43	332	3.7	1,075	0.40	89	0.51	278	353	2,200	0.31	7-14
7-28	118	230	74	8.40*		5.5	2.40	13	1.37	64	52	638	41	356	4.9	1,015	0.40	100	0.51	300	373	2,158	0.32	7-28
8-11	107	2,300	77	8.55*		9.2	1.49	10	1.92	57	59	750	48	348	6.8	1,200	0.31	103	0.38	297	385	2,515	0.22	8-11
8-25	151	2,300	69	8.35*		8.1	2.51	12	1.71	67	52	525	31	374	4.6	805	0.44	95	0.50	314	379	1,822	0.26	8-25
9-8	134	110	70	8.45*		5.8	2.07	7	0.85	62	52	560	44	350	5.4	900	0.48	94	0.47	296	367	1,930	0.31	9-8
9-23	718	46,000	58	8.45*		2.8	2.21	14	1.97	59	54	161	22	267	5.8	274	0.31	78	0.42	316	367	898	0.20	9-23
STATION NO. 2 MALAD RIVER																								
1958																								1958
7-29	19.5	23,000	70	8.15			5.38	7	5.0	68	60	326	30	461	3.6	498	-	131	1.30	384	415	1,382	0	7-29
8-26	22.5	3,900	69	8.55			1.57	16	1.9	100	26	200	17	368	7.2	272	0.34	108	0.62	314	358	958	0.24	8-26
9-23	61	2,300	57	8.35			3.25	36	5.9	117	47	700	60	483	6.0	1,120	0.10	135	0.77	406	487	2,398	0.93	9-23
10-29	78	2,300,000+	49	7.70			14.20	19	1.3	89	56	511	63	454	1.3	805	0.34	121	0.71	374	450	1,928	0.41	10-29
11-25	110	1,100,000	41	7.45			30.57	34	5.8	100	84	590	59	539	0.84	980	0.18	145	0.61	443	594	2,265	0.37	11-25
12-22	82	9,300	37	8.25			4.19	33	1.5	130	64	642	52	456	4.5	1,003	0.22	207	0.92	381	585	2,401	0.33	12-22
1959																								1959
1-27	90	93,000	38	7.95			8.07	24	17.0	119	57	607	48	443	2.2	957	0.44	184	0.60	367	529	2,262	0.38	1-27
2-24	150	9,300	40	7.90			6.34	20	14.0	57	46	286	28	319	1.4	445	0.08	129	0.56	264	331	1,234	0.31	2-24
3-24	92	1,100,000	47	8.15			5.20	22	4.4	161	43	715	63	456	3.5	1,126	0.40	214	0.43	380	581	2,625	0.08	3-24
4-28	6	9,300	55	8.15			5.45	15	2.3	76	75	920	59	467	3.6	1,283	0.56	285	0.98	389	495	3,004	0.50	4-28
5-26	36	9,300	57	8.15			4.17	16	16.0	65	39	396	33	358	2.8	525	0.44	100	0.47	298	324	1,417	0.32	5-26
6-23	10	3,900	74	8.25			3.38	13	3.8	74	36	374	30	367	3.6	538	0.44	112	0.48	307	334	1,398	0.28	6-23
7-14	25	43,000	72	8.30*			3.42	11	4.1	56	49	280	22	408	4.5	386	0.40	104	0.63	342	342	1,150	0.30	7-14
7-28	35	9,300	69	8.40*			2.62	12	6.0	62	44	180	13	388	5.4	217	0.40	101	0.44	327	335	854	0.21	7-28
8-11	26	15,000	75	8.50*			2.36	11	2.5	61	57	342	29	463	8.1	413	0.52	140	0.78	393	386	1,305	0.30	8-11
8-25	32	24,000	63	8.30*			3.56	15	4.4	65	49	227	13	425	4.7	255	0.52	99	0.55	356	364	951	0.28	8-25
9-8	30	46,000	65	8.35*			2.69	9	1.9	60	45	180	11	400	4.9	258	0.58	92	0.35	336	352	911	0.26	9-8
9-23	65	240,000	36	8.25*			3.95	31	8.0	90	49	445	56	300	4.2	721	0.35	123	0.83	359	427	1,768	0.40	9-23

* Field Determinations

TABLE C II

Sampling Date	Discharge (cfs)	M P N Coliform per 100 ml.	Temperature ° F. *	pH	Concentration in milligrams per liter: Dissolved Oxygen * (D.O)	Biochemical Oxygen Demand (B.O.D.)	Free Carbon Dioxide (CO_2)	Silica (SiO_2)	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Chlorides (Cl)	Nitrates (NO_3)	Sulfate (SO_4)	Fluoride (F)	Alkalinity ($CaCO_3$)	Hardness ($CaCO_3$)	Total Dissolved Solids (T.D.S.)	Boron (B)	Sampling Date
STATION NO. 8 BEAR RIVER																								
1959																								1959
3-24	1,405	1,500	46	8.25			3.14	13	2.06	76	29	31	8	341	3.34	62	0.48	47	0.33	285	310	478	0.13	3-24
4-28	1,690	23	53	8.25			2.45	10	2.0	48	31	33	5	267	2.62	45	0.40	35	0.23	223	245	353	0.13	4-28
5-26	47	1,500	59	8.40			2.02	10	1.12	47	39	205	16	300	4.16	329	0.56	63	0.53	253	279	875 1/	0.23	5-26
6-23	30	150	77	8.35			2.00	13	1.67	55	34	212	17	297	3.68	329	0.35	61	0.38	250	278	874 1/	0.08	6-23
7-14	45	930	77	8.40*			2.26	14	2.23	52	44	184	16	336	4.66	275	0.35	74	0.47	283	309	850	0.21	7-14
7-28	45	140	73	8.50*			0.79	14	3.65	52	42	213	14	331	5.78	289	0.31	78	0.48	281	304	889	0.21	7-28
8-11	45	23,000	76	8.55*			1.65	12	0.70	49	59	71	7	386	7.55	79	0.31	78	0.28	329	364	543	0.18	8-11
8-25	45	930	66	8.35*			2.40	14	3.24	56	46	162	15	357	4.41	225	0.35	78	0.47	300	327	993	0.16	8-25
9-8	45	930	70	8.45*	Not Determined	Not Determined	1.99	10	1.21	58	41	175	10	336	5.22	262	0.40	73	0.48	284	314	811	0.23	9-8
9-23	115	3,900	57	8.50*			1.85	14	0.75	62	47	74	13	262	6.18	105	0.31	72	0.40	309	349	600	0.22	9-23
STATION NO. 3 BEAR RIVER																								
1958																								1958
7-29	451	2,300	72	8.20			3.78	8	2.3	63	38	71	8	387	3.3	80	1.4	74	0.75	315	315	520	0	7-29
8-26	24	930	70	8.40			2.29	17	1.1	80	32	156	19	339	4.7	238	0.24	69	0.48	286	332	772	0	8-26
9-23	1,010	230	59	8.55			1.71	23	1.5	63	43	73	12	400	7.8	75	0.40	62	0.33	341	338	533	0.13	9-23
10-28	1,100	7,500	47	8.20			3.48	11	0.88	70	38	51	10	348	3.0	66	0.34	68	0.24	290	330	477	0.08	10-28
11-25	1,674	9,300	35	8.00			5.47	12	0.28	93	22	60	9	347	1.9	64	0	62	0.31	288	324	485	0.11	11-25
12-22	920	930	35	8.35			2.32	13	0.41	72	35	49	7	344	4.3	61	0.96	50	0.64	290	325	467	0.07	12-22
1959																								1959
1-27	1,652	150	35	8.25			3.08	14	0.41	73	31	57	8	335	3.3	54	0.78	43	0.35	280	308	445	0.08	1-27
2-24	1,487	430	38	8.15			4.16	17	1.2	68	38	55	7	357	2.8	62	0.08	51	0.41	297	327	505	0.13	2-24
3-24	1,355	2,300	46	8.20			3.32	14	2.0	76	29	45	8	332	2.9	68	0.44	54	0.28	277	310	479	0.10	3-24
4-28	2,585	150	52	8.20			2.56	9	2.1	47	27	31	4	255	2.2	41	0.52	27	0.25	213	231	330	0.19	4-28
5-26	20	150	60	8.25			2.56	11	0.63	53	30	159	10	279	2.7	246	0.30	35	0.65	233	254	707	0.17	5-26
6-23	20	230	73	8.30			2.36	14	0.72	72	21	190	11	282	3.1	290	0.35	40	0.26	236	267	767	0.16	6-23
7-14	22	93	75	8.2 *	7.7	2.1	3.04	12	0.75	59	38	162	11	330	3.2	236	0.40	53	0.40	276	304	752	0.18	7-14
7-28	21	430	76	8.3 *	8.3	3.5	3.01	12	0.96	54	45	179	9	336	4.7	248	0.31	68	0.42	283	318	805	0.17	7-28
8-11	24	2,300	76	8.6 *	7.6	2.1	3.64	13	0.82	49	54	146	10	369	5.1	216	0.35	67	0.37	311	343	781	0	8-11
8-25	25	230	66	8.2 *	6.8	1.7	3.85	13	0.59	65	41	156	11	352	3.9	242	0.35	59	0.41	295	330	795	0.15	8-25
9-8	23	140	69	8.2 *	9.3	1.3	3.45	8	0.61	58	44	181	10	342	3.8	286	0.44	62	0.47	287	326	865	0.20	9-8
9-23	830	930	60	8.5 *	8.5	3.5	1.35	14	0.81	65	45	70	13	260	5.7	88	0.35	67	0.33	308	347	571	0	9-23

* Field Determination

1/ Sum of constituents

TABLE C III

Sampling Date	Discharge (cfs)	M P N Coliform per 100 ml.	Temperature ° F.*	pH	Concentration in milligrams per liter: Dissolved Oxygen* (D.O.)	Biochemical Oxygen Demand (B.O.D.)	Free Carbon Dioxide (CO_2)	Silica (SiO_2)	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Chlorides (Cl)	Nitrate (NO_3)	Sulfate (SO_4)	Fluoride (F)	Alkalinity ($CaCO_3$)	Hardness ($CaCO_3$)	Total Dissolved Solids (T.D.S.)	Boron (B)	Sampling Date
STATION NO. 9 HAMMOND CANAL																								
1959																								1959
5-26	141	93	58	8.35	Not Determined	Not Determined	1.89	10	1.29	49	28	48	8	281	3.47	58	0.26	2	0.27	236	237	396	0.12	5-26
6-23	163	230	73	8.25			2.67	12	1.63	63	23	51	8	291	2.85	67	0.17	39	0.23	243	253	423	0.12	6-23
7-14	162	430	75	8.25*			3.25	12	1.31	58	41	69	11	353	3.46	85	0.30	58	0.40	295	313	516	0.16	7-14
7-28	157	430	76	8.35*			1.59	12	1.56	58	43	71	9	356	4.40	82	0.35	75	0.35	289	323	554	0.16	7-28
8-11	145	930	73	8.40*			2.62	14	1.01	49	56	72	11	388	5.38	81	0.35	76	0.28	327	354	583	0.08	8-11
8-25	167	1,400	66	8.35*			2.45	12	0.79	50	49	72	10	364	4.50	75	0.35	44	0.39	306	327	530	0.13	8-25
9-8	167	430	70	8.35*			2.40	8	1.56	64	40	68	11	357	4.40	83	0.48	62	0.33	300	324	543	0.18	9-8
9-23	60	910	59	8.50*			1.84	13	0.85	65	45	66	13	260	6.14	80	0.35	68	0.33	307	347	544	0.16	9-23
STATION NO. 4 LITTLE BEAR RIVER																								
1958																								1958
7-29	89	230	76	8.15			3.98	9	1.70	70	25	26	6	341	2.7	28	0.44	42	0.71	284	279	378	0	7-29
8-26	100	1,500	65	8.35			2.22	15	0.87	65	27	17	2	306	3.8	18	0.30	33	0.40	257	274	332	0	8-26
9-23	114	1,500	57	8.40			2.28	19	1.20	100	8	26	7	338	4.7	18	0.60	30	0.31	285	284	351	0.07	9-23
10-28	238	930	46	8.20			2.86	9	0.70	70	20	8	2	285	2.5	13	1.0	26	0.17	238	256	287	0.09	10-28
11-25	270	750	37	8.15			3.40	8	0.57	93	8	11	6	318	2.5	15	0	21	0.31	265	265	303	0.03	11-25
12-22	270	430	37	8.20			2.77	9	0.52	75	44	15	7	277	2.4	12	0.96	23	0.46	231	259	308	0	12-22
1959																								1959
1-23	345	2,300	38	8.10			3.56	10	0.53	64	26	16	3	285	2.0	15	0.30	27	0.37	237	258	306	0.53	1-23
2-24	392	4,300	40	8.00			4.67	12	0.92	65	28	15	4	297	1.6	15	0.04	30	0.33	246	272	333	0.07	2-24
3-24	362	43,000	47	8.25			2.34	7	1.60	68	15	13	2	255	2.5	13	0.48	22	0.27	213	231	281	0.05	3-24
4-28	731	430	48	8.15			2.66	9	1.80	46	23	10	2	228	1.8	13	0.74	16	0.05	190	209	255	0	4-28
5-26	234	930	54	8.20			2.69	9	1.10	52	25	15	3	268	2.4	16	0.74	26	0.31	224	233	308	0.11	5-26
6-23	177	2,300	68	8.10			3.62	14	12.00	70	20	17	5	290	2.0	18	0.87	23	0.17	241	255	328	0	6-23
7-14	73	930	75	8.10*	6.9	6.0	3.50	11	1.10	61	28	23	4	300	2.3	24	0.17	44	0.30	250	265	370	0.13	7-14
7-28	85	4,300	75	8.30*	5.5	2.5	3.01	12	2.80	71	24	24	5	319	3.1	24	0.35	41	0.27	267	278	385	0.13	7-28
8-11	115	2,300	74	8.40*	5.7	2.1	2.40	12	0.86	64	28	21	4	318	2.8	21	0.58	27	0.24	265	276	351	0	8-11
8-25	143	930	63	7.90*	5.5	1.6	5.55	12	3.60	79	19	24	4	315	2.2	20	0.52	31	0.25	262	277	362	0.13	8-25
9-8	101	2,100	66	8.10*	6.3	1.7	4.02	8	1.10	64	30	22	5	312	2.7	26	0.96	19	0.35	260	281	367	0.13	9-8
9-23	241	4,300	56	8.40*	8.3	1.0	1.91	11	0.57	48	36	14	5	295	2.9	17	0.96	21	0.28	247	267	325	0.08	9-23

* Field determinations

TABLE C IV

Sampling Date	Discharge (cfs)	M P N Coliform per 100 ml.	Temperature ° F. *	pH	Concentration in milligrams per liter: Dissolved Oxygen* (D.O.)	Biochemical Oxygen Demand (B.O.D.)	Free Carbon Dioxide (CO_2)	Silica (SiO_2)	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Chlorides (Cl)	Nitrate (NO_3)	Sulfate (SO_4)	Fluoride (F)	Alkalinity ($CaCO_3$)	Hardness ($CaCO_3$)	Total Dissolved Solids (T.D.S.)	Boron (B)	Sampling Date
										STATION NO. 5 BEAR RIVER														
1958																								1958
7-29	732	390	73	8.25			3.43	7	1.9	58	46	67	8	373	1.8	76	0.82	81	0.75	312	334	530	0	7-29
8-26	1,100	930	69	8.45			2.40	15	1.6	80	52	52	7	405	6.3	73	0.30	76	0.44	343	354	548	0	8-26
9-23	775	430	57	8.55			1.78	17	1.2	75	53	78	14	416	8.2	83	0.44	71	0.37	355	366	560	0.14	9-23
10-28	725	230,000	47	8.25			0.04	11	0.70	72	47	52	11	384	3.8	66	0.40	86	0.30	321	371	532	0.10	10-28
11-25	660	23,000	36	8.05			6.00	13	0.93	98	26	72	10	425	2.6	68	0	46	0.40	351	350	552	0.14	11-25
12-22	905	73	35	8.25			3.50	14	1.1	75	44	15	7	380	3.7	52	0.96	63	0.58	31	366	495	0.09	12-22
1959																								1959
1-27	740	7,500	35	8.10			5.09	19	1.0	78	43	60	8	408	2.8	54	0.78	64	0.43	339	372	531	0.08	1-27
2-24	870	930	37				SAMPLE BROKEN																	2-24
3-24	825	7,500	43	8.15			4.37	16	3.1	83	32	45	9	375	2.9	54	0.62	69	0.25	312	340	497	0.15	3-24
4-28	1,250	2,300	49	8.05			3.76	16	5.0	48	29	34	6	266	1.7	45	0.62	35	0.17	221	238	358	0.09	4-28
5-26	600	430	56	8.25			3.09	12	1.6	52	37	69	12	336	3.3	106	0.34	47	0.43	281	284	548	0.17	5-26
6-23	520	930	71	8.20			-	17	3.6	71	29	86	13	336	2.9	105	0.44	57	0.31	280	296	554	0.06	6-23
7-14	478	230	72	8.30*	6.3	2.7	2.61	13	1.7	64	47	77	12	388	4.8	95	0.65	75	0.42	326	354	602	0.15	7-14
7-28	968	2,300	73	8.50*	5.8	6.3+	2.10	11	1.3	60	47	71	8	380	5.3	82	0.35	75	0.38	320	344	577	0.19	7-28
8-11	806	9,300	71	8.30*	6.2	2.7	3.42	13	1.6	49	58	75	11	396	4.9	84	0.44	74	0.28	333	361	588	0.05	8-11
8-25	403	2,300	66	8.40*	6.5	2.5	2.63	12	1.0	53	54	70	11	392	1.7	87	0.48	73	0.38	324	353	546	0.16	8-25
9-8	598	23,000	66	8.30*	6.9	4.7	3.40	9	0.84	65	49	72	10	399	4.9	98	0.58	74	0.58	335	365	610	0.20	9-8
9-23	413	2,300	57	8.60*	7.7	1.9	1.05	12	1.2	65	41	81	14	256	5.6	116	0.52	58	0.47	303	330	601	0.21	9-23
										STATION NO. 6 CUB RIVER (Location changed 7-14-59. See Appendix C)														
1958																								1958
7-29	25	4,300	65	7.95			5.63	4	2.7	70	16	32	3	306	1.5	36	3.0	20	0.33	253	241	336	0	7-29
8-26	12	1,500	62	8.25			3.01	15	0.92	70	28	30	4	328	1.8	40	1.4	30	0.37	274	274	388	0	8-26
9-23	14	2,300	54	8.20			3.43	18	1.6	88	9	35	9	343	3.0	23	1.7	17	0.31	286	257	376	0.09	9-23
10-28	32	2,300,000+	48	7.25			50.5	15	0.59	112	41	27	69	564	0.55	28	0.4	28	0.34	463	448	877	0.08	10-28
11-25	57	2,300,000+	42	7.25			55.14	15	1.1	100	34	31	39	550	0.48	17	0	24	0.34	452	390	658	0.08	11-25
12-22	44	43	34	8.00			5.57	15	0.57	76	26	19	6	353	2.0	20	0.52	15	0.66	293	296	362	0.01	12-22
1959																								1959
1-27	57	430	34	7.55			-	16	0.96	70	23	24	7	323	0.74	25	0.74	13	0.43	266	270	363	0.08	1-27
2-24	95	2,300	35	7.80			8.46	17	3.9	57	30	39	9	331	1.1	37	0.22	26	0.38	273	263	410	0.2	2-24
3-24	85	39,000	42	7.85			5.51	12	3.6	56	15	22	2	247	0.96	20	0.82	12	0.32	204	201	269	0.07	3-24
4-28	445	930	45	7.95			3.02	14	6.8	33	12	7	2	157	0.84	3	0.74	8	0.02	142	145	201	0	4-28
5-26	85	43,000	52	8.00			3.97	13	4.1	48	19	16	4	252	1.4	16	0.96	13	0.28	209	198	284	0.09	5-26
6-23	48	9,300	63	7.95			5.06	13	3.7	70	12	17	4	255	1.4	21	2.3	5	0.17	230	224	285	0	6-23
7-14	18	1,400	70	8.2*	8.45	7.2+	3.23	8	1.2	58	21	21	3	277	2.2	29	1.0	9	0.23	231	230	298	0.08	7-14
7-28	28	7,500	68	5.2*	5.55	1.4	3.12	8	3.5	71	16	21	3	290	2.5	29	0.44	10	0.12	242	243	334	0.10	7-28
8-11	16	4,300	68	8.2*	5.85	2.6	3.15	10	1.8	60	26	25	3	307	2.4	31	1.4	12	0.14	256	256	344	0	8-11
8-25	13	1,400	62	8.0*	5.70	2.6	4.77	11	2.1	66	26	34	6	306	2.5	48	0.65	24	0.28	265	272	394	0.15	8-25
9-8	26	23,000	54	8.0*	6.10	1.9	5.04	6	1.4	64	26	29	5	317	2.5	45	1.2	16	0.35	264	267	353	0.09	9-8
9-23	13	2,300	54	8.3*	7.15	2.0	2.58	14	1.5	45	24	24	5	310	2.4	32	1.3	12	0.36	258	252	375	0.12	9-23

*Field determinations

TABLE C V

Sampling Date	Discharge (cfs)	M P N Coliform per 100 ml.	Temperature ° F. *	pH	Concentration in milligrams per liter: Dissolved Oxygen * (D.O.)	Biochemical Oxygen Demand (B.O.D.)	Free Carbon Dioxide (CO_2)	Silica (SiO_2)	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Chlorides (Cl)	Nitrate (NO_3)	Sulfate (SO_4)	Fluoride (F)	Alkalinity ($CaCO_3$)	Hardness ($CaCO_3$)	Total Dissolved Solids (T.D.S.)	Boron (B)	Sampling Date
STATION NO. 22 CUB RIVER																								
1959																								1959
7-14	17	930	62	8.2 *	9.5	4.9	3.29	8	0.27	62	20	20	3	282	2.2	28	1.0	9	0.20	235	236	293	0.10	7-14
7-28	25	2,300	59	8.0 *	7.2	3.6	5.25	9	2.0	75	14	21	3	303	1.7	25	0.31	9	0.13	251	246	317	0.09	7-28
8-11	13	4,300	60	8.0 *	6.5	2.0	5.20	11	0.53	60	28	25	4	319	2.0	29	1.5	13	0.13	265	265	334	0.08	8-11
8-25	10	290	55	7.8 *	6.0	1.5	7.75	11	0.42	72	25	30	6	305	1.6	34	0.88	17	0.19	253	280	361	0.12	8-25
9-8	18	1,100	57	7.7 *	6.1	1.4	10.10	7	0.43	65	25	27	10	309	2.2	40	1.8	42	0.02	257	265	370	0.11	9-8
9-23	10	360	49	7.9 *	6.6	1.3	4.61	13	0.40	49	37	22	5	223	2.2	29	1.2	13	0.23	187	276	340	0.09	9-23
STATION NO. 16 CUB RIVER																								
1959																								1959
7-14	7	2,300	67	7.8 *	1.3	6.1	7.51	13	1.5	62	30	47	11	378	1.7	42	0.26	28	0.38	313	278	434	0.18	7-14
7-28	12	2,300	70	7.7 *	0.5	2.3	9.50	12	0.9	69	30	65	12	397	2.2	60	0.40	43	0.32	329	294	494	0.20	7-28
8-11	6	24,000	66	8.2 *	1.1	8.6	4.10	14	4.0	56	34	65	17	399	1.8	47	0.52	30	0.40	330	278	471	0.23	8-11
8-25	5	11,000	61	7.8 *	1.5	7.0	10.75	12	1.8	63	33	46	13	403	1.8	44	0.52	24	0.42	334	291	466	0.18	8-25
9-8	11	1,400	62	8.1 *	3.0	6.2	4.30	9	2.2	48	27	42	6	331	2.2	34	0.70	21	0.41	275	230	393	0.20	9-8
9-23	4	23,000	52	8.2 *	5.5	2.6	3.35	17	2.1	45	32	24	5	315	3.9	18	1.4	10	0.50	262	242	365	0.13	9-23
STATION NO. 7 BEAR RIVER																								
1958																								1958
7-29	757	930	72	8.35			2.58	7	1.7	58	59	75	11	383	4.7	124	3.3	80	0.84	322	386	626	0	7-29
8-26	1,088	930	69	8.55			2.10	15	0.88	70	30	99	16	332	5.8	127	0.40	81	0.44	282	365	652	0.20	8-26
9-23	761	930	56	8.55			1.85	19	1.0	75	57	50	13	434	8.5	72	0.18	76	0.32	370	376	556	0.13	9-23
10-28	693	73	46	8.25			3.80	12	0.59	72	49	77	11	414	4.1	101	0.3	81	0.31	346	379	585	0.13	10-28
11-25	603	230	35	8.30			3.09	14	0.36	93	31	57	10	339	4.1	113	0	13	0.56	309	358	582	0.14	11-25
12-22	861	23,000	35	8.35			2.57	15	0.68	79	41	61	10	382	4.7	82	0.96	59	0.69	321	367	527	0.10	12-22
1959																								1959
1-27	683	93	34	8.15			4.70	19	0.58	105	26	85	10	403	3.2	104	0.96	66	0.49	336	368	614	0.13	1-27
2-24	775	230	37	8.10			5.07	19	3.7	85	42	94	12	407	2.8	112	0.08	71	0.61	338	382	652	0.15	2-24
3-24	740	430	43	8.20			3.64	17	2.2	87	33	73	13	363	3.2	103	0.48	74	0.33	303	353	576	0.15	3-24
4-28	805	91	46	8.25			3.00	13	1.3	55	39	65	9	326	3.2	86	0.34	50	0.30	273	298	504	0.12	4-28
5-26	515	230	54	8.25			3.21	12	1.3	57	38	105	15	349	3.4	139	0.52	62	0.56	292	299	615	0.83	5-26
6-23	472	930	70	8.30			3.98	14	3.4	76	32	95	17	355	3.9	138	0.17	71	0.33	298	319	612	0.20	6-23
STATION NO. 13 BEAR RIVER																								
1959																								1959
7-14	460	930	69	8.3 *	6.6	2.0	2.40	13	0.9	55	49	71	11	357	4.4	82	0.17	78	0.37	300	338	542	0.20	7-14
7-28	940	9,300	68	8.3 *	5.6	2.8	3.20	11	1.2	64	48	70	8	384	5.3	83	0.35	83	0.38	324	358	591	0.30	7-28
8-11	790	930	69	8.8 *	6.2	3.2	1.25	17	1.1	46	48	197	17	340	6.7	281	0.26	77	0.47	290	313	904	0.18	8-11
8-25	390	230	64	8.4 *	7.1	2.2	2.70	14	1.0	63	52	138	16	410	6.4	167	0.40	78	0.63	347	371	756	0.20	8-25
9-8	570	1,100	64	8.4 *	6.7	2.4	2.80	9	0.93	64	54	69	11	404	6.3	85	0.52	84	0.33	342	378	700	0.20	9-8
9-23	400	140	56	8.5 *	8.5	1.1	1.90	13	0.88	55	56	125	21	383	0.7	170	0.44	72	0.47	315	368	695	0.20	9-23

* Field Determination